

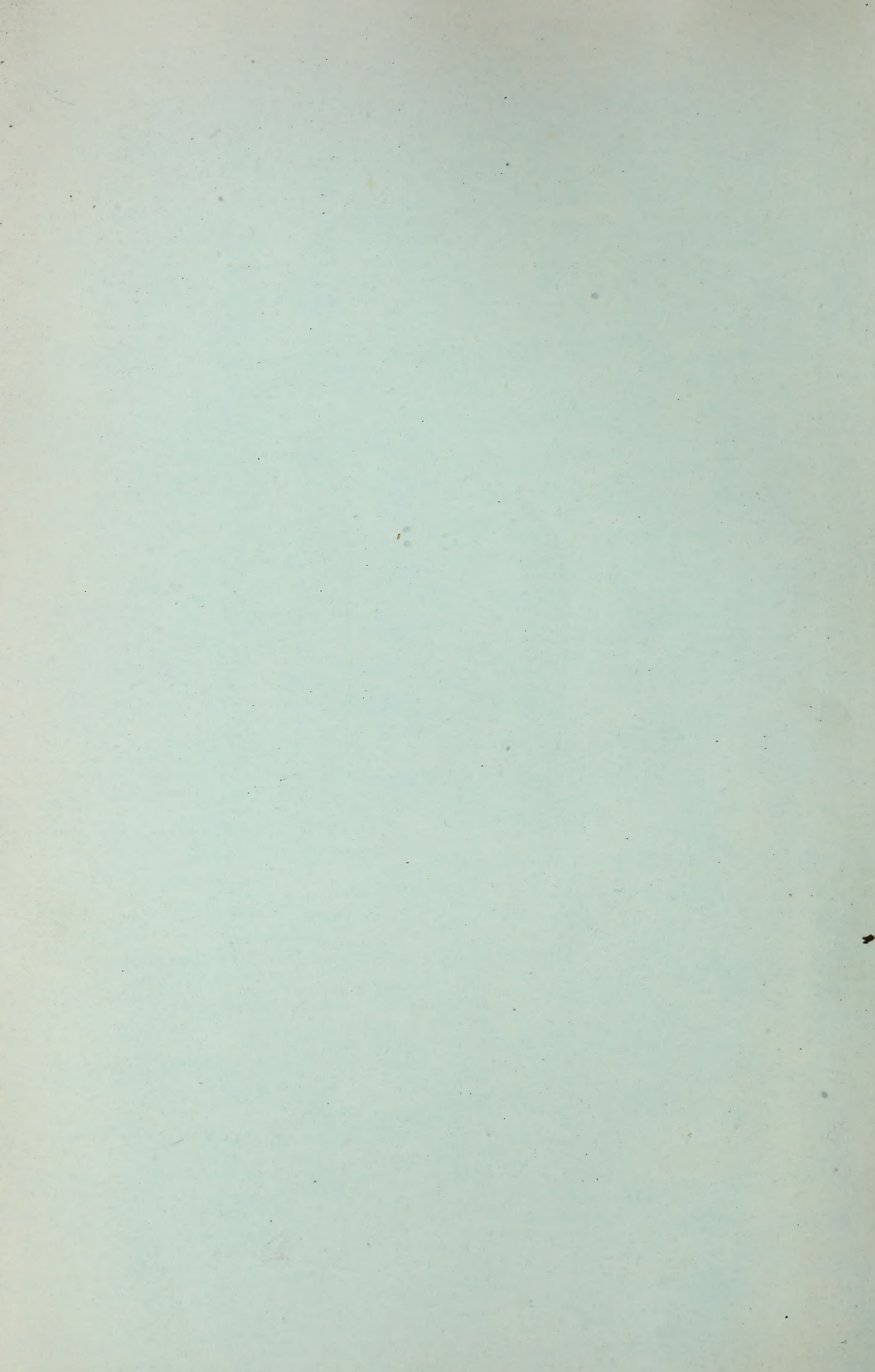
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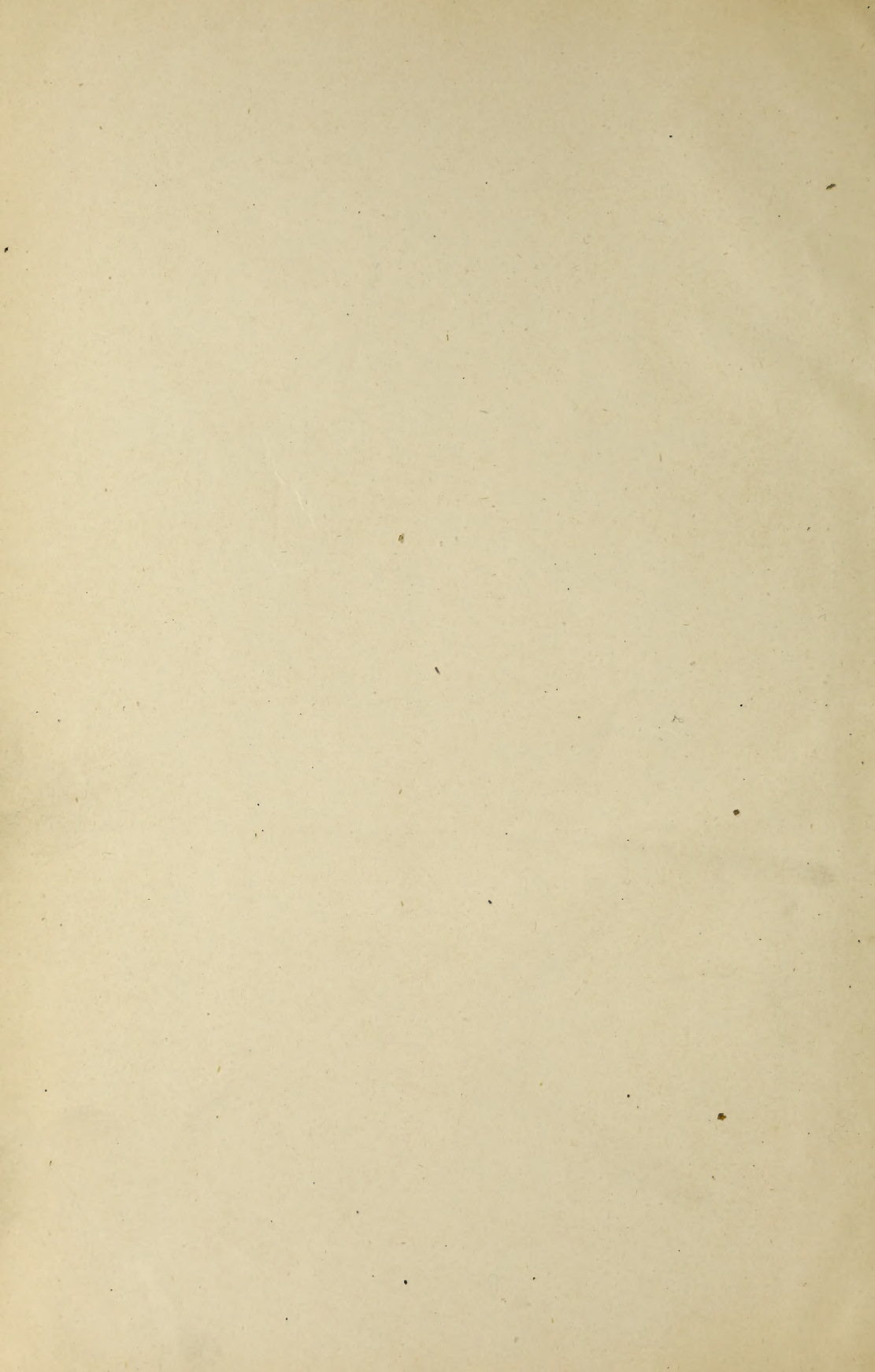
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THE
INTERNATIONAL ENCYCLOPÆDIA
OR
SURGERY.

VOL. IV.



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THE
INTERNATIONAL ENCYCLOPÆDIA
OF
SURGERY

A SYSTEMATIC TREATISE
ON THE
THEORY AND PRACTICE OF SURGERY
BY
AUTHORS OF VARIOUS NATIONS

EDITED BY
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PENNSYLVANIA HOSPITAL, ETC.

ILLUSTRATED WITH CHROMO-LITHOGRAPHS AND WOOD-CUTS

IN SIX VOLUMES
VOL. IV.

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THE INTERNATIONAL ENCYCLOPÆDIA OF SURGERY.

ARTICLES CONTAINED IN THE FOURTH VOLUME.

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INJURIES OF THE BACK, INCLUDING THOSE OF THE SPINAL COLUMN, SPINAL MEMBRANES, AND SPINAL CORD. By JOHN A. LIDELL, A.M., M.D., Late Surgeon to Bellevue Hospital, New York; also Late Surgeon U.S. Volunteers in charge of Stanton U.S. Army General Hospital, Inspector of the Medical and Hospital Department of the Army of the Potomac, etc. Page 261.

MALFORMATIONS AND DISEASES OF THE SPINE. By FREDERICK TREVES, F.R.C.S., Assistant Surgeon to, and Senior Demonstrator of Surgery at, the London Hospital. page 487

INJURIES AND DISEASES OF THE EYES AND THEIR APPENDAGES. By E. WILLIAMS, M.D., Professor of Ophthalmology in Miami Medical College, Cincinnati. Page 561.

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DISEASES AND INJURIES OF THE NOSE AND ITS ACCESSORY SINUSES. By GEORGE M. LEFFERTS, M.A., M.D., Clinical Professor of Laryngoscopy and Diseases of the Throat in the College of Physicians and Surgeons, Medical Department of Columbia College, New York; Consulting Laryngoscopic Surgeon to St. Luke's Hospital, etc. Page 751.

INJURIES AND DISEASES OF THE FACE, CHEEKS, AND LIPS. By ALFRED C. POST, M.D., LL.D., Emeritus Professor of Clinical Surgery in the University of the City of New York; Consulting Surgeon to the New York Hospital, St. Luke's Hospital, the Presbyterian Hospital, and the Woman's State Hospital. Page 849.

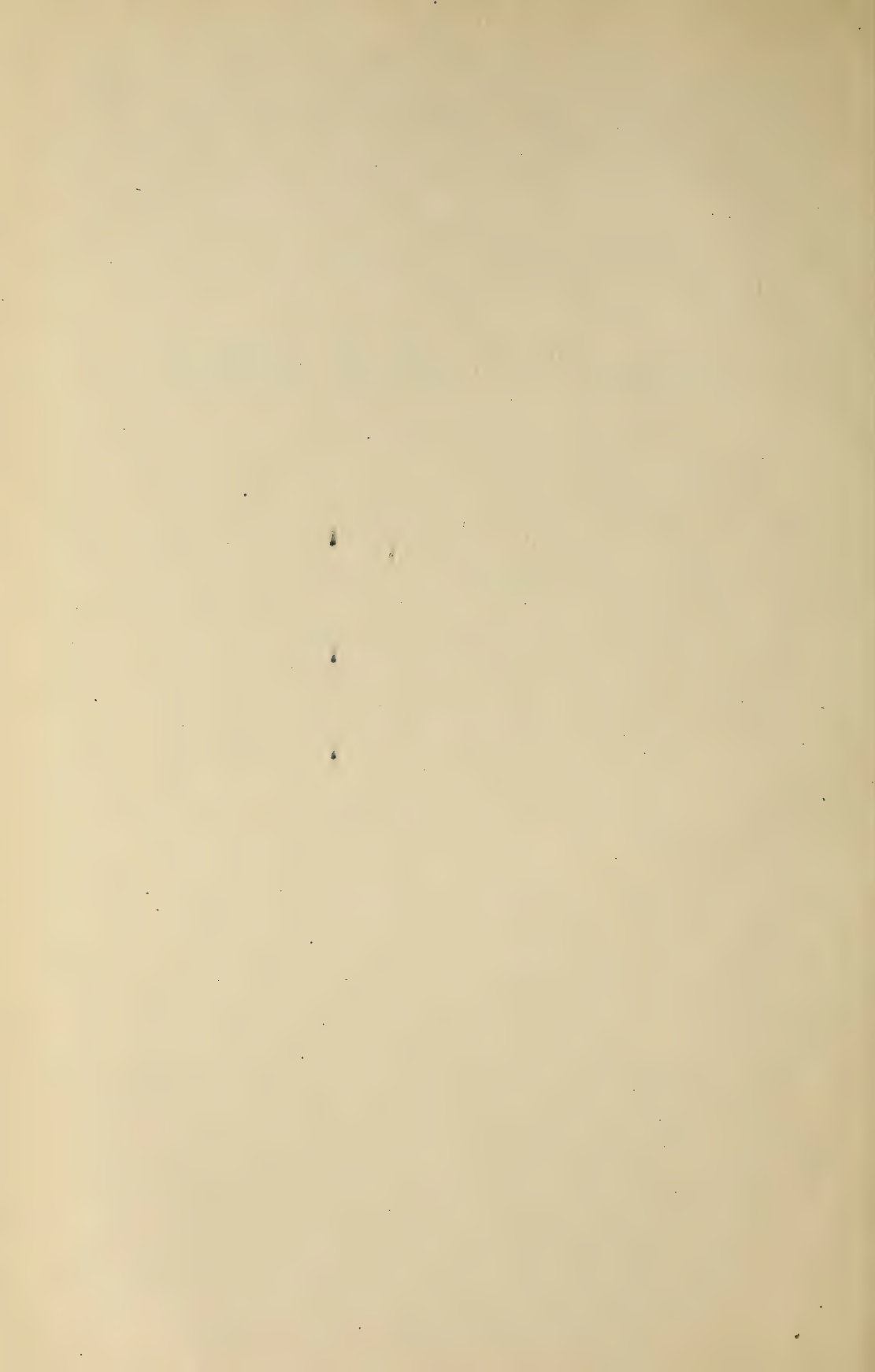
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SURGERY OF THE TEETH AND ADJACENT PARTS. By NORMAN W. KINGSLEY, M.D.S., D.D.S., Late Professor of Dental Art and Mechanism in the New York College of Dentistry. Page 943.

ALPHABETICAL LIST OF AUTHORS.

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By

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By

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THE INTERNATIONAL ENCYCLOPÆDIA OF SURGERY.

INJURIES OF BONES.

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FRACTURES.

THE main function of the bony skeleton and of its accessory cartilages is passively mechanical.¹ They constitute a framework for the suspension and protection of the viscera, and for the utilization of muscular force in the performance of all voluntary movements, as well as in the automatic function of breathing. By their construction and arrangement, the bones and cartilages are adapted to bear all the strain put upon them in the ordinary course of life, but they are sometimes subjected to violence beyond their power of resistance, and fracture or breakage is the result.

A very large proportion of the cases which present themselves to the surgeon, whether in hospital or in private practice, are those of broken bones; and for this reason, as well as on account of the gravity of the conditions often involved, and the probable permanency of any untoward result, it is a matter of much moment that this subject should be thoroughly studied, and in the most practical manner. An accurate acquaintance with normal anatomy is essential; and no opportunity of examining fractures, whether in the living body or in the dead, in recent or in old specimens, should be neglected. Clinical experience, such as is gained in hospitals, is of great value, as are also mechanical ability and dexterity in the adaptation and application of apparatus. The habit of gentleness of touch, and of firm and skilful handling of injured parts, should be sedulously cultivated.

It may be said further, that out of no other class of cases have arisen so many suits for malpractice. The reason of this is not difficult to perceive.

¹ Rindfleisch has recently pointed out the important part taken by the *marrow* of bones in the formation of the red corpuscles of the blood; but this has not yet been shown to have any surgical interest.

Lameness in the lower extremity, or disability in the upper, will fix the attention of the patient, and attract the notice of others. Sometimes the surgeon may have indiscreetly promised, during the treatment, perfect recovery, or may have overlooked restlessness, or even disobedience, on the part of the patient. Sometimes the latter is struck with the more favorable result of other cases as compared with his own; and sometimes, unfortunately, the idea of bringing suit is suggested to him by meddling friends or pettifogging lawyers. But whatever may be the origin of such proceedings, they are always annoying and vexatious, often expensive, and generally injurious to the surgeon, even if the verdict should be in his favor. Hence, it is highly desirable that they should be avoided, as far as possible, by the exercise of the utmost skill, care, and discretion, in the management of the injuries now in question.

There are some fractures which are serious by reason of the danger of loss or impairment of the function of the bone itself, and in which, therefore, the main object of the surgeon's treatment must be the most perfect possible restoration of the normal form and relations of the bone. Such are those of the humerus, the femur, and the bones of the leg or forearm.

Others derive their gravity chiefly from the risk of involvement of contained viscera; such are those of the skull, vertebræ,¹ ribs, and pelvis. Even in fractures of the long bones, there are sometimes such injuries inflicted upon the neighboring soft parts, bloodvessels, or nerves, or both, as to produce the gravest results. Cases of this kind will be noted in connection with fractures, especially, of the clavicle, femur, and bones of the leg.

Every bone in the body is liable to fracture; but, as will further appear, some bones are much more exposed, and much more frequently broken, than others. And just as the normal function of these organs is carried on in exact accordance with the laws of mechanics, so in their fractures the working of the same laws may be traced. In the general discussion of the whole subject, fractures of the long bones will be kept in view, not only because they are more frequent, but because they afford the best and most convenient illustrations of the phenomena presented.

The points for study in regard to these injuries are: their causes; the mechanism of their production; their varieties; the phenomena and symptoms attending them; their diagnosis; their consequences; their complications; the mode of their repair and deficiencies in this process; their prognosis; and the principles of their treatment. All these topics will be first taken up in a general way, and they will subsequently be considered in reference to the several bones.

CAUSES OF FRACTURE.

Fractures are always caused by force, and by adequate force; although under certain circumstances it may and does seem as if the bones gave way, as it were, of themselves. Hence the term "spontaneous" has been used; but, as will be hereafter shown, it is not strictly correct.

The causes of fracture may be divided into *immediate* and *predisposing*. Under the former head are embraced the various forms of violence under which bones give way, while under the latter belong all conditions, whether of the body at large, of the skeleton, or of the individual bones, which expose the latter to fracturing forces, or make them more ready to yield.

¹ Fractures of the skull and of the vertebræ are so generally attended with lesions of the great nerve-centres, and these lesions give rise to questions of such magnitude and such special interest, that these subjects will be hereafter dealt with in separate articles.

IMMEDIATE CAUSES.—It would be vain to try to enumerate all the special forms of violence by which, in the complicated conditions of human life, bones are broken. But they may be classified under four general heads: direct and indirect violence, muscular action, and avulsion.

Direct violence is that which is inflicted upon the bone at the point where the fracture occurs; such as a blow with a stick or a stone, the passage of a wheel over a limb, or the fall of a heavy body upon it. Here the momentum of the impinging mass is expended in overcoming the resistance of a portion of the bony tissue.

Indirect violence is that which is transmitted through some length of the bone, which becomes an overtaxed lever; as, for example, when a man falls from a height, alighting upon his feet, and the femur gives way at some portion of its shaft. Here the resistance of the ground, acting through the foot and leg, fixes the lower end of the femur, while the momentum of the body continues to drive the upper end of this bone downward; and the natural curve of the shaft is increased until its texture gives way.

As will presently be further shown, there is often also an element of twisting added to the leverage.

Muscular action, when it causes fracture, must either be extremely violent and sudden, as in cases of convulsion or very powerful effort, or the bone must be taken at a disadvantage, as will be further explained in speaking of the mechanism of fractures generally, as well as of those of special bones.

Fractures by *avulsion* are those in which a small fragment of bone is torn away by the stress put upon ligamentous structures attached to it. They are more generally known at present as “sprain-fractures,” and the observations to be made concerning them will be found in connection with fractures close to the joints, especially of the knee and ankle.

So many illustrations of the foregoing statements will be given in discussing the mechanism of fractures, as well as in describing these injuries as affecting special bones, that I shall dwell no further upon them here; only saying that in very many cases the agency of indirect force is greatly aided by the occurrence of muscular contraction at the moment of its application.

PREDISPOSING CAUSES.—Among the *general* diseases which have been thus ranked by authors, there are some which admit of much doubt. Thus, in regard to *gout*, *rheumatism*, and *scurvy*, there seems to be no evidence that they render the bones more fragile; although they may possibly, by crippling or weakening the limbs, make their victims clumsy, and less able to avoid falls or escape violence. Yet it must be remembered that persons so diseased are obliged to take care of themselves, and to abstain from the active pursuits which would involve exposure to the usual fracturing forces.

Scrofula has been placed by some writers in this category, but there is really no evidence that it belongs here. Its subjects are sometimes ill-nourished and feeble, and very probably their bones, like their tissues generally, are weak in texture. But many of the scrofulous are strong and active, and in these there is no sign of fragility of the bones unless they are actually affected with caries, and not always then. After healing has taken place, the osseous tissue seems to be condensed and peculiarly firm, although the constitutional disorder may be still progressing.

Syphilis has been assigned by some as a cause of fragility of the bones, and many cases are on record in support of their views. Berkeley Hill¹ mentions a case in which a child six weeks old, already affected with snuffles and pemphigus, sustained a fracture of the left humerus by the mother “catching the

¹ Syphilis and Local Contagious Disorders, 2d ed. London, 1881.

arm in a hole in the towel with which the child was being dried. When the child was examined, the right clavicle was bent and thickened with callus near its middle, where it had been broken at some time unknown to its mother. The fractured bone united in the usual manner." He also speaks of fractures occurring in syphilitic children during their birth, quoting a case recorded by Porak;¹ and says that "in adults the bones occasionally give way under a trifling strain." Gross² mentions the case of a man aged 31, whose humerus gave way as he threw a small chip at a dog. He had had syphilis seven years before, and was at the time subject to nocturnal pains in the arm and forearm. Prof. Chiari, of Prague,³ maintains that the occurrence of "gummos osteomyelitis," or central gummata, in the medullary structure of the long bones, is not rare, and may afford an explanation of these cases of apparently spontaneous fracture. But when we consider, first, the immense number of syphilitic patients constantly under observation, and the rarity of fractures among them, and secondly, the fact that in many persons presumably free from any such taint the bones give way to seemingly inadequate force, it must be admitted that the basis of the theory that syphilis weakens the bony structures is but a slight one. Only a very few instances have been reported in which fractures have taken place at the seat of the so-called tertiary lesions.⁴

Cancer is another malady which has long had the reputation of affecting the strength of the osseous system. But here also the fact would seem to be that it is only when local manifestations of the constitutional taint occur in the bones, that these organs show any unusual fragility. At least we may say, as in the case of syphilis, that in view of the great number of cases of cancer constantly under the eyes of the profession, it is strange that fractures without local deposit should so seldom occur, if the pathological change in the bones were really an element in the natural history of the disease.

It is otherwise with regard to certain *disorders of the nervous system*, which are attended with such degeneration of the nerve centres as to affect the trophic innervation of many organs, and especially of the skeleton. Perhaps the bones betray this influence the more readily by reason of their low grade of organic activity. Attention seems to have been first drawn to this subject by Davey,⁵ who reported the case of an insane person, an autopsy upon whom disclosed six so-called "spontaneous" fractures—three in the two femora, and three in the humerus, radius, and clavicle respectively. At a later period, the frequency with which fractures of the ribs were found in patients dying in lunatic asylums, attracted notice; it was thought that these lesions were due to maltreatment by attendants, until the publication of numerous observations by Pedlar,⁶ Hearder,⁷ and others, showed softening of the bones to be one of the elements of a tabetic condition apt to occur in the later stages of insanity. The bones of two insane persons dying with fractured ribs, are said by Ormerod⁸ to have been dark, wet, greasy, easily decomposed, enlarged, and with thin outer walls; under the microscope they showed much fatty matter, and a granular condition like ossifying cartilage.

According to T. L. Rogers,⁹ the organic constituents of the bones in a

¹ Gaz. Méd. de Paris, 1877, p. 538.

² System of Surgery, vol. i. p. 898, 6th ed., 1882.

³ Phila. Med. Times, Feb. 10, 1883, from Vierteljahrsschr. für Dermatologie und Syphilis.

⁴ Arnott, London Med. Gazette, June 5, 1840.

⁵ Medical Times, Dec. 24, 1842.

⁶ West Riding Lunatic Asylum Report, 1871.

⁷ Journal of Mental Science, Jan. 1871.

⁸ St. Bartholomew's Hospital Reports, vol. vi. 1870.

⁹ Liverpool Med. and Surg. Reports, vol. iv. 1870.

similar case were in larger amount, and the proportion of lime to phosphoric acid less, than normal; the bones resembling those of the fœtus. Moore¹ placed upon record a case of "osteomalacia" in a woman, aged 70, the subject of acute mania, who had had at different times four fractures, and who died soon after the fourth. He does not appear, however, to have recognized this "breaking down of the bone-tissue" as dependent upon the disease of the central nervous system.

In 1867 I made an autopsy in the case of the late Dr. Pennock,² who had been long a paralytic; the bones were all so soft as to be easily cut with a knife, and presented much the same appearance as those above mentioned, although no fracture had taken place.

Dr. Weir Mitchell, in 1873,³ in an article on "Rest in Locomotor Ataxia," said: "It naturally occurs to ask why so many ataxies have chanced to break limbs? and as to this I should answer, first, that no people are so awkward or fall so much; and, next, that in some of the cases it seemed to me that the habitual abruptness of the muscular acts had a share in the calamity, and that I have suspected, what has not yet been proved, that the bones in ataxies may suffer some impairment of their nutrition, and hence of their strength."

Charcot⁴ reported a very remarkable case, in which several fractures occurred in the person of an ataxic woman; and referred, with assent, to the suggestion of Mitchell, just quoted. Further observations were communicated to the Pathological Society of London, in 1880, by Buzzard,⁵ and the subject was discussed by Hutchinson and others.

A lady, about 60 years of age, was under my care in 1879, who had long been paraplegic, and who, by catching her foot against a cushion as she was lifted into a carriage, sustained a fracture of both bones of the right leg; just about a year previously she had broken the other leg from an equally slight cause. A very similar case, in a man of 65, was placed on record by Mr. Busk.⁶

Professor Bruns, of Tübingen, has published a very interesting paper,⁷ based upon the case of an ataxic woman, æt. 57, who had sustained fractures, at different times, of both forearms; the right without known cause, the left in lifting a plate. He gives a long list of references to articles, by various authors, bearing upon the subject, and defines the change which occurs in the bones as an eccentric atrophy, with rarefaction of the compact substance, and filling of the widened marrow-spaces with fat. Ross,⁸ speaking of tropho-neuroses, says:—

"Spontaneous fractures have attracted the attention of surgeons from a remote period, but these accidents were attributed to the influence of certain diatheses, such as gout, rheumatism, scrofula, and cancer. Larrey drew special attention to the fact that a certain form of paralysis of the lower extremities was associated with a strong predisposition to fractures of their bones. In the record of this case, however, it is mentioned that the so-called paralytic symptoms were associated with amaurosis and great exaltation of the sensibility of the lower extremities, which renders it almost certain that the symptoms were not due to paralysis, but to ataxia. In 1873, Weir Mitchell drew attention to the frequency of spontaneous fractures in locomotor ataxia, and suggested

¹ St. George's Hospital Reports, 1871-2.

² See American Journal of the Medical Sciences, July, 1868.

³ Ibid., July, 1873.

⁴ Arch. de Physiologie, Janvier, 1874.

⁵ Brit. Med. Journal, Feb. 14, 1880. The reader may refer with advantage to another article by Buzzard, "On the Affection of the Bones and Joints in Locomotor Ataxy," in the British Medical Journal for March 5, 1881.

⁶ London Medical Gazette, April 10, 1840.

⁷ Spontan-fracturen bei Tabes. Berl. klin. Wochenschr., March 13, 1882.

⁸ Treatise on Diseases of the Nervous System, 1881, vol. i. p. 224.

that during the progress of the disease the bones had undergone nutritive changes which greatly diminished their resistance. This subject was subsequently investigated by Charcot and his followers, with their usual thoroughness and success. The period of fracture is usually preceded by two or three paroxysms of lancinating pain of unusual severity; and at the same time the limb is found swollen, and with all the symptoms of osteo-periostitis, and fracture occurs on the slightest movement of the limb, or in the entire absence of any movement or other external cause. The femur is more frequently fractured than any other bone, the seat of fracture being frequently the neck of the former; but the bones of the leg, arm, forearm, and, indeed, almost every bone of the limb and trunk, have been found fractured, including the vertebral column. Multiple fractures in the same patient are by no means uncommon, and in a case published by Charcot, the patient, towards the close of life, could scarcely move in bed without fracturing some one or other of the few bones which had not been already fractured. Damaschino has drawn attention to the fact that the spontaneous fractures of ataxies reunite very readily and rapidly, with an enormous formation of callus."

Dr. Debove, in a communication to the Paris Hospital Society, observed that in his practice at the Bicêtre, he had frequent occasion to see fractures in the subjects of hemiplegia, these fractures always occurring on the hemiplegic side, there being every reason to believe that changes took place in such cases in the osseous tissue, rendering it more fragile. In one case of chronic hemiplegia he found that not only the fractured bone itself, but all the bones on the same side, had undergone such change. They were less heavy than on the sound side, the medullary canal was larger, and the substance of the diaphysis was less compact. Examined histologically, the Haversian canals were found much dilated, and the bone porous. Chemical examination also showed that the diaphysis contained a larger quantity of fat. These fractures usually consolidated rapidly, the callus being somewhat voluminous.¹

It would seem clear, from the foregoing, that there is in many forms of central nervous disease, including hemiplegia, paraplegia, locomotor ataxia, general paralysis of the insane, and perhaps other allied conditions, a state of defective nutrition brought about in the bones, whereby they are rendered either softer or more brittle, and which causes them to yield very readily to slight fracturing forces. Very possibly, further study of the subject may throw additional light upon the whole series of changes; but the statement just made is an embodiment of what is now known with regard to it.

Rachitis, or rickets, a disease supposed by most writers to be almost wholly unknown in this country,² has been not unfrequently observed as a predisposing cause of fracture by British and Continental surgeons. It affects children chiefly, and is manifested by softening and distortion of the bones, with enlargement of their articular extremities. It may be that such cases often occur among the lower classes of our negroes, the parents being ill-fed, poorly clothed, and often strumous or syphilitic; and that the deformed limbs so commonly seen in that race among us, are the traces of congenital rickets.

Hamilton³ mentions a case seen by him in 1853, in which, in an infant four days old, born of a healthy mother and at full time, "nearly all of the

¹ Medical Times and Gazette, Oct. 29, 1881; from Gaz. des Hôpitaux, 20 Oct. 1881.

² See the article on Rachitis, by Dr. J. Lewis Smith, Vol. I. p. 251. In the American Journal of the Medical Sciences for January and April, 1872, the reader may find an admirable discussion of this disease by the late Dr. John S. Parry, who says he "has been irresistibly forced to the conclusion that rachitis is scarcely less frequent in Philadelphia than it is in the large cities of Great Britain and the continent of Europe, and that it should occupy just as important a place in our mortuary lists as Hillier conceives that it should in those of the registrar-general of England."

³ Practical Treatise on Fractures and Dislocations, 6th ed., 1880, p. 33.

long bones were separated and movable at their epiphyses, the motion being generally accompanied with a distinct crepitus. The bones were also much enlarged in their circumference; the bones of the forearm and the femur were greatly curved; the fontanelles were unusually open; and the clavicles were entirely wanting. The child was of full size, but looked feeble. It died in a condition of marasmus six months after birth; at which time some degree of union had taken place at several of the points of separation, the limbs having been supported constantly with pasteboard splints and rollers."

A case was reported by Collins to the Manchester Medical Society,¹ in which a condition allied to rickets seemed to have been brought about in a child by the deficiency of casein in the mother's milk. The child was born January 2, 1882; when first seen, January 13, the left femur presented every appearance of having been fractured and recently united. On the 30th, the left humerus was found to be broken; on February 20, the right humerus, and on February 24, the right femur. Each fracture was at the centre of the shaft, and there was in no instance any evidence of violence or injury. There was no history of syphilis; the child's bones were curved. All the fractures united readily.

As illustrative of the more pronounced cases of rickets, I may quote from Malgaigne² a case recorded by Jacquemille:—

The patient was "born of healthy parents, but affected from his first year with general rachitis, which had flattened his ribs, distorted his spine, and curved all the long bones except the humerus. He could not walk till five years old, and remained always excessively small and feeble. Toward the age of twelve, in climbing a wood-pile, he fell and broke the right arm at the middle. The fracture was simple, and united perfectly. At fifteen, trying to get up behind a carriage, he lost his footing, and fractured both thighs; which uniting with deformity, he was permanently crippled on the right side. At seventeen, he broke the left arm. At twenty-eight, he broke the left thigh, at a different point from before. Finally, at thirty-two, he again broke the right thigh, likewise at a new point. The case was now lost sight of."

Mr. R. Barwell³ lately showed to the Pathological Society of London—

A girl, aged 17, but apparently very much younger, who presented a most extraordinary series of deformities. Her family history threw no light on her condition, which was not congenital. In her mental development she was juvenile rather than weak, and she had not reached puberty. Very few of her bones were free from deformity. Both humeri were much bent, but especially the right; so that, on that side, whereas the humerus measured seven inches and a half, the length of the arm from acromion to olecranon was only four inches and a quarter; again, the right tibia measured nine inches and a half, but the length of leg was only four inches and a half. This was owing to the bone, at about the lower fourth, being bent back on itself, so that it ran upwards and parallel to the rest of the bone. The left olecranon process was greatly lengthened, and placed at an obtuse angle to the shaft of the bone. . . . The bones, a few years ago, had been remarkably brittle, and still remained so, but to a less degree. Between the ages of 9 and 13, she had broken her arms four times, and her lower limbs on several occasions. There was no bending of the ribs, nor any enlargement of the epiphyses.

Mr. Barwell did not think that the case could be classed either with rickets or with osteo-malacia. He had had under his care, some years ago, a boy who presented similar deformities, but less marked, and he had endeavored to straighten the femur. On cutting down to it, however, he found that on the slightest force the chisel sank through the whole structure of the bone,

¹ Brit. Med. Journ., May 13, 1882.

² *Traité des Fractures et des Luxations*, tome i. p. 20; Translation, p. 33.

³ Brit. Med. Journ., Dec. 9, 1882.

and about five fluidounces of liquid fat flowed out. Both of these patients suffered from pain referred to the convex side of the distorted bone. He thought that there was hypertrophy of the medulla at the expense of the bone proper.

J. Cloquet¹ says: "M. Esquirol possesses, in his anatomical collection, the skeleton of a rachitic female, in whom nearly all the bones of the limbs and trunk are covered with the traces of fractures more or less well united; several of them are broken in two, three, or four points of their length. These fractures, more than two hundred in number, appear to have occurred at different times, judging from the varying states of the callus." It is not easy to say what was the real nature of this remarkable case, but it is scarcely likely that it was one of ordinary rachitis; more probably it belonged among the now recognized tropho-neuroses.

As a general rule, when rachitic children survive the period of the second dentition, the skeleton acquires firmness, and even becomes remarkably dense and strong. Hence it might be questioned whether the adult cases just quoted should fairly be regarded as belonging under this head. But the condition known as *mollities ossium*, *malacosteon*, or *osteo-malacia*—"softening of the bones," in plain English—would seem really to differ very little from that which in children goes by the name of rickets; and Jacquemille's patient may have simply passed from one into the other. Rickets, then, would be the *mollities ossium* of children, *mollities ossium* the rickets of adults; an idea long ago suggested. But this view must not be too implicitly accepted, since in rickets, although the pathological changes noted in the bones are more those of sub-acute inflammation, there is little or no pain; while in the *mollities ossium* of adults, a disorder in which fatty degeneration seems to be a very important element, the pains are excessive. The tendency of the former, under anything like favorable circumstances, is toward spontaneous cure; recovery from the latter has never yet been recorded. Of the published cases of *mollities*, the subjects have been for the most part females. In some, large amounts of phosphates and of "animal matters" are said to have been excreted with the urine.²

Further reference need hardly be made to *mollities ossium*, especially as it is highly probable that the cases hitherto ranged under this head may be found to belong properly among the tropho-neuroses before spoken of, the changes connected with the bony skeleton being altogether subordinate to those affecting the central nervous system. Such would seem to be the explanation, in the light of the science of our day, of the classical cases recorded by Curling, Solly,³ Saviard,⁴ and others.

I ought, however, to remark that in some instances the softening is limited in extent; thus in a case reported by the late Dr. Neill,⁵ one femur only seemed to be affected. The theory of the neurotic origin of the disease is not here set aside, but we have simply to suppose that a portion only of the central nervous system has undergone pathological change, and that as a result there is degeneration of that part of the skeleton which is dependent upon the tract so involved.

Fragilitas ossium, or brittleness of the bones, differs from the already mentioned predisposing causes of fracture in being not as much a disease as a

¹ Article "Fractures," *Diet. de Médecine*. Paris, 1824.

² Solly, *Med.-Chir. Trans.*, vol. xxvii. p. 443; MacIntyre, *ibid.*, vol. xxxiii.; Chambers, *ibid.*, vol. xxxvii.

³ Curling, *Med.-Chir. Transactions*, vol. xx.; Solly, *ibid.*, vol. xxvii.

⁴ Malgaigne, *op. cit.*, tome i. p. 21; Translation, p. 33.

⁵ *Am. Journal of the Med. Sciences*, July, 1874.

peculiarity. Sometimes it is seen in old people, as one of the changes incident to their time of life; but it has also been observed as a congenital condition, and in rare instances as a matter of heredity, so that many members of a family, and even several generations, may manifest it. From the published accounts, it does not appear that the bones of persons affected with fragility are always, or even generally, small or slight, and their muscular development would seem to be quite equal to the average standard. A few instances only need be here quoted at length.

Dr. F. J. Shepherd reported to the Medico-Chirurgical Society of Montreal¹ a case of senile atrophy of the bones, with very remarkable fragility, in a woman aged between 80 and 90.

Tyrrell² thus reports a remarkable case of brittleness of bone in a man whose age is not given:—

He had been the subject, at the time he was last under my hands, of seventeen fractures; and when I last saw him, three or four years ago, he had had five more fractures, making in all twenty-two. These fractures affected the femur, the tibia and fibula, the upper arm, and the forearm—scarcely a cylindrical bone of any size had escaped. In consequence of these fractures he had lost in height from seven to eight inches. The first time I had him under my care was in consequence of fracture of the thigh-bone, and the other had been fractured once or twice previously. In consequence of indifferent surgery, that limb was shorter by three inches than that for which he came under my care. He had worn an iron to make up for the difference in the length of the two limbs, and it enabled him to make progression with some inconvenience. Finding this, I stated that it was possible to set the recently broken limb to the same length as the one formerly broken, and at his wish I did so. I made an angular union of the second limb, reduced it to the same length as the other, and he was enabled afterwards to make progression more easily and rapidly. Hence I was the instrument of taking off three or four inches from his height, by shortening the limb to that extent.

It may not be anticipating too much to say here that it is difficult to see how walking could have been facilitated by making the leg crooked; and the experiment is certainly one which surgeons of the present day would hesitate to try.

Gibson³ gives the following case of his own:—

A patient of mine, a Mr. Green, residing near Trenton, N. J., has a son now nineteen years of age, who, from infancy up to the present period, has been subject to fractures from the slightest causes, owing to an extraordinary brittleness of the bones. The bones of the arm, forearm, thigh, and leg, have all been broken repeatedly, even from so trivial an accident as catching the foot in a fold of carpet whilst walking across the room. The clavicles have suffered more than any other bone, having been fractured eight times. What is remarkable, the boy has always enjoyed excellent health, and the bones have united without much difficulty or much deformity. The above was published in 1824; since then this patient died, in the twenty-third year of his age. . . . Altogether he had experienced twenty-four fractures.

Stanley⁴ speaks of a boy aged ten, under the care of Mr. Earle, in St. Bartholomew's Hospital, "who had suffered eight fractures, six in one tibia, and two in the femur. Each fracture of the tibia occurred in a different part of the bone, and had united within the usual period."

In a case reported by Arnott,⁵ a girl aged fourteen years was under treatment for her thirty-first fracture; the right thigh having been broken seven

¹ Medical News, Nov. 18, 1882.

² St. Thomas's Hosp. Reports, vol. i. 1836.

³ Institutes and Practice of Surgery, 8th ed. (1850), vol. i. p. 234.

⁴ A Treatise on Diseases of the Bones. London, 1849.

⁵ London Med. Gazette, June 15, 1833.

times, the left six; the right leg nine times, the left once; the right arm four times, the left three; and the left forearm once. Her sister, six years old, had had nine fractures since the age of eight months. Neither of her parents nor their families had shown any such susceptibility, nor had it appeared in another sister, or in two brothers.

Agnew¹ mentions a child seen by him who had twice broken the same thigh; he was one of a family of six children, every one of whom had suffered from fracture, two of these three times each. The father had had syphilis, a fact which was supposed to account for the fragility of the bones of his offspring.

Gurlt quotes from Axmann another case, in which three brothers showed this tendency to the occurrence of fracture.

Of fragility affecting the bones in several generations, a very few instances have been given, but they are beyond doubt.² Goddard³ saw a boy aged twelve, who had had fourteen fractures, all from slight violence; his mother had broken her right thigh once, and her left five times; and her brother, at thirteen years, had suffered two fractures of one thigh, and nine of the other, as well as two of the arm. "These people," says the record, "are of very short stature, and have small bones."

Pauli⁴ gives the history of a family in the parish of Offenbach, "three of whom had twice, and one thrice, broken an arm and a leg, while one had five times suffered fractures of one or another limb, slight force only having been as a rule sufficient to produce the lesions. Both the father and grandfather had had bones broken. The family were otherwise healthy, and presented no discoverable dyscrasia. It is remarkable that none of them sustained fractures before they were eight years of age. The fractures united very quickly, so that the callus was generally perfectly firm by the end of three weeks. But if the same bone was broken a second time, union did not take place."

In a case reported by Greenish,⁵ a boy aged 18 had himself had thirteen fractures; his grandfather had had "numerous" fractures; his father one; his uncle two; his five cousins (children of his uncle), eight, four, four, four, and three respectively; his own brother, two. One uncle and his two daughters had escaped.

[The editor has recorded a case in which, without apparent reason, seventeen fractures had been sustained by the bones of the right lower extremity; when this patient came under observation, multiple enchondromata had been developed in the foot and ankle.]

A few words may be said on the influence of *age, sex, and occupation* upon the liability of individuals to fracture; they are so closely connected in this respect that they may be considered together.

Until about the age of puberty, the habits, plays, and occupations of boys and girls are very much alike, and one might naturally suppose that their bones would be broken with about equal frequency. Yet according to Malgaigne, from two to five years of age, "the number of girls affected with fracture was nearly double that of the boys;" while Gurlt⁶ gives the proportion: from one to four years $1\frac{1}{2}$ times as many, and from five to eight years $2\frac{1}{3}$ times

¹ Principles and Practice of Surgery, vol. i. p. 718.

² Ekman's case, quoted by Gurlt from Acrelius (A. D. 1788), seems to me not to belong in the present category, but to have been simply an instance of hereditary rachitis, as far as the vagueness of the account enables one to judge.

³ Gibson, op. cit., vol. i. p. 236.

⁴ Untersuchungen und Erfahrungen im Gebiete der Chirurgie, 1844; quoted by Gurlt, Handbuch der Lehre von den Knochenbrüchen, Bd. i. S. 149.

⁵ Brit. Med. Journ., June 26, 1880.

⁶ Op. cit., table on p. 9.

as many boys as girls. The two authors just quoted agree in saying that between the fifteenth and twentieth years of life about eight times as many fractures occur in males as in females. Malgaigne thinks that the disproportion then steadily diminishes, until "beyond seventy-five years there are nearly twice as many fractures in women as in men;" but Gurlt makes the proportion between twenty-one and thirty 10 times, and between thirty-one and forty $11\frac{1}{2}$ times as many male as female cases. Then, according to the latter author, a decrease does occur, and from seventy-one to eighty the women are $2\frac{1}{2}$ times, and from eighty-one to ninety 7 times, as often affected with fractures as men. I shall make no attempt to reconcile or explain the differences between these estimates, coming from such distinguished sources.

Children sustain fractures mainly as the result of falls; but they are very liable to be hurt in this way, partly from their lack of muscular strength, partly from their heedlessness and love of adventure. Occasionally they put themselves in danger from the kicks of horses, or from being run over; I once had to amputate the arm of a little fellow, only seventeen months old, for compound fracture caused by the wheel of a passenger railway car.

After puberty, the rougher sports of boys render them much more liable than girls, not only to falls, but to other forms of violence; and during adult life, many of the occupations followed by men are attended with numerous exposures from which women are almost wholly exempt. Our hospital wards afford daily evidence of the liability to fracture among painters, carpenters, masons, drivers, and laborers of all kinds.

With the advent of old age, the habits of the two sexes become again much more nearly alike, and the accidents to which both are exposed resemble those which are apt to happen to children. Senile feebleness, and the timidity which comes with it, is curiously similar in its effect, in this way, to the ignorant and heedless weakness of childhood. And the slighter frames of women yield more readily to sudden strains, so that the excess in the number of their fractures is not a matter of wonder.

Not only is the frequency of fractures influenced by the causes just discussed, but their character also. In children and in the youth of both sexes, we have to deal mainly with fractures (sometimes incomplete) of the shafts of the long bones, and with epiphyseal disjunctions. In adults we meet with injuries of the former class, and (chiefly in the male sex) with fractures by crushing, as in mining, railroad, and machinery accidents, and falls from heights. Among old people, the bones are more apt to give way, from slight force, at weak points; thus in them fractures of the neck of the femur are very common. But these points will be again referred to more particularly.

Drunkenness has been spoken of by some authors as a source of immunity from fracture; and in proof of this idea cases are adduced in which persons have fallen from considerable heights, while under the influence of liquor, without sustaining any injuries beyond contusions. But there are very many instances known in which sober people have likewise escaped fractures; and on the other hand, a large proportion of the patients admitted into hospitals, or treated in private, for this class of hurts, have received them while drunk. The only way in which intoxication can prevent fracture is by relaxing the muscles, and thus rendering the limbs flaccid. Under such circumstances one of the conditions of indirect force as a cause of fracture is set aside, and the bones, if broken, yield to direct violence or crushing.

The influence of *season*, and especially of cold weather, as a predisposing cause of fracture, was insisted on by some of the older writers, who maintained that the bones were more brittle in winter. This idea need hardly be gravely refuted. When the ground is frozen hard, and rendered slippery by

ice and snow, falls upon it are perhaps more apt to result in fracture of bones; but on the other hand, in milder weather, out-door occupations are more extensively carried on, whether in the way of work or of sport, and a great many accidents occur to those engaged in them.

Something may now be said of the *local* predisposing causes of fracture.

The *exposed situations* of certain bones, and of certain portions of those bones, render them especially liable to breakage. Tables are given by systematic authors, derived mainly from hospital records, showing with more or less accuracy the relative distribution of fractures over the skeleton, from a comparison of large numbers of cases. Such tables, as far as I have been able to find and compare them, agree in sustaining the following general statement of the comparative liability to fracture of the different portions of the skeleton: The greatest number of fractures occur in the bones of the leg; then follow the thigh, the arm, the forearm, the clavicle, the ribs, the facial bones (including of course the lower jaw), and the patella. A more detailed exhibit would scarcely be of practical value here, but can be found in the writings of Malgaigne, Gurlt, Norris, and others, by those who may be interested in the matter.

Inflammation of a bone has been assigned as a cause of such weakening of its texture as to render it apt to give way. Nicod's two cases, quoted by Malgaigne,¹ seem to bear this explanation; in each the patient had had pains for about a month in the humerus, which broke under very slight stress.

Caries and *necrosis*, by depriving a bone of a portion of its thickness, may lead to the snapping of the remainder.

Tubercle of bone may so alter it as to make it unequal to the resisting of fracturing forces; and in a very few instances the same result has been recorded of *cystic* or *hydatid tumors*. For details of five such cases, the reader is referred to Gurlt.² With regard to the development and natural history of *sarcomata* of the long bones, by which they have sometimes been similarly affected, much information may be found in a paper by Dr. S. W. Gross.³ The central sarcomata would seem to be those most apt to weaken the bony structures so as to predispose them to fracture.

SPONTANEOUS FRACTURES.—*Spontaneous* fractures, so called, are such as occur without any apparently adequate cause. Thus Erichsen⁴ says that he knew a gentleman a little over fifty years of age, seemingly in perfect health, whose thigh gave way with a loud snap as he turned in bed. Gross⁵ mentions the case of a gentleman aged 54, who broke his femur in pulling off a boot. Other like instances are on record.

In a larger class of cases, there is evidence more or less clear of a precedent diseased condition of the bones; and to designate these, Prof. Broca⁶ suggested "pathological" as a more accurate term. Thus there may have been previous complaint of pain at or near the seat of fracture; and in some cases malignant disease has been present at the time, as in those recorded by Salter and S. Cooper.⁷ Sometimes there is a local development of the disease in the bone, previous to its giving way, as in the case quoted from Petit by Malgaigne;⁸ or again, the fracture is the first sign of the bone becoming

¹ Op. cit., tome i. p. 23; Translation, p. 34.

² Op. cit., S. 193.

³ American Journal of the Medical Sciences, July and October, 1879.

⁴ Science and Art of Surgery, 1873 (Am. ed.), vol. i. p. 303.

⁵ Op. cit., vol. i. p. 899.

⁶ Gaz. des Hôpitaux, 15 Avril, 1876; Med. Times and Gazette, May 13, 1876.

⁷ Salter, Med.-Chir. Transactions, vol. xv.; Cooper, ibid. vol. xvii.

⁸ Op. cit., tome i. p. 13; Translation, p. 26.

affected, as in an instance recorded by myself.¹ Hydatids (*cysticercus cellulose*) are sometimes found in bone, and the first indication of the disease has sometimes been the occurrence of fracture without apparent cause.²

Still another set of cases are thus known, in which the bones give way under abnormal muscular action, as in epileptic or other convulsions. Lente³ has recorded an instance in which both femora were so fractured. Van Oven⁴ reported a fracture of the femur, by cramp coming on during sleep, in his own person. Many other cases have been published, some of which will be hereafter referred to in connection with the special bones involved. As a general rule, if the muscular action be not clearly pathological, such as that exerted in epileptic states, it is sudden and forcible; and the fact can often be demonstrated that the bones thus broken are taken at a mechanical disadvantage. Sometimes, as I shall point out in regard to certain parts of the skeleton, there is a probability of leverage being the true explanation of these apparently causeless yieldings.

It will therefore be seen that the term "spontaneous," if used at all, should be clearly understood either to refer only to the first of the classes of cases just enumerated, or to have a simply conventional meaning, namely, that the force producing the fracture is not obviously adequate to the breaking of a sound bone. For it cannot be imagined that turning in bed, for instance, or throwing a chip, should involve sufficient strain upon the structure of a normal femur or humerus to cause the fibres to give way. Indeed, in the first class of cases, it may be regarded as almost certain that some pathological change had taken place in the bones, although undetected; the accounts do not state whether or not there was any further evidence of disease, but such a thing is quite possible.

As to the third class, any one familiar with the fearful force of muscular action often manifested by patients affected with epilepsy or tetanus, will see the absurdity of applying the word "spontaneous" to fractures occurring under such circumstances.

Nothing ever occurs spontaneously, either in normal or in pathological phenomena; although it may be that the chain is not traceable without closer observation or clearer insight than is brought to bear upon it.

MECHANISM OF THE PRODUCTION OF FRACTURES.

It has already been remarked that the main function of the bony skeleton, and of each of its component parts, is mechanical, and is carried on in accordance with the known laws of mechanics. Further than this, each bone is a member of a system, made up of two or more bones, united together by ligaments, and moved upon one another more or less freely by the action of muscles, so that the mechanical conditions involved are somewhat complex, and can only be arrived at by the study of the structure, form, and connections of the members of each system. When the strain put upon a bone is beyond its power of resistance, its fracture takes place in obedience to the same laws, and under the influence of the same conditions. Hence, if any one studies a large number of fractures, placing them in series according to the portion of the skeleton involved, he may readily note a certain uniformity which prevails among the different members of each series. Variations do indeed exist, but they are traceable to differences, perhaps slight, in the char-

¹ Malgaigne, Translation, p. 26.

² Stanley, *op. cit.*, pp. 190, 194; Wickham's case, from London Medical and Physical Journal, vol. lvii.

³ Amer. Med. Times, July 21, 1860.

⁴ Med. Times and Gazette, Dec. 25, 1852.

acter, direction, or exact mode of application of the fracturing force, or in the conditions of resistance, or perhaps in the shape of the bones themselves. The dominant lines of breakage are singularly constant; and although they have been pointed out in regard to certain special fractures, they have been overlooked in the general study of these injuries.

No such uniformity exists in the case of china, marble, or plaster. A bowl or statue, struck or thrown down, may be shattered into fragments of the

Fig. 802.



Diagram supposed to represent extra-capsular fracture of the cervix femoris. An impossible line of fracture.

most fantastic and apparently capricious shapes. Or if several exact models of a femur were made in plaster, and force applied to them, they would be cracked, shivered, or broken off short, in the most irregular way. The annexed outline (Fig. 802) is taken from a cut which has been used by eminent authors as a representation of extra-capsular fracture of the cervix femoris; but I will venture to say that no one ever saw such a fracture, and that any one will be convinced of its impossibility who will look at a vertical section of the head and neck of the femur. What the dominant lines really are, will be shown when the discussion of fractures of this part comes in order.

Only a brief review can be given here of the mechanical conditions of the skeleton; but the general principles laid down will be found to be verified in the case of special bones and their fractures.

Upon an exterior survey, it is at once seen that the long bones are narrow in their shafts, and expanded at either end for the purpose of strengthening the articulations. It will be also noted that they are almost without exception curved, and that many of them are twisted in a marked degree. These irregularities of form are more pronounced in some skeletons than in others. Some of the bones, notably the lower jaw and the femur, are strongly bent.

Upon making sections—of the femur for instance, this bone affording the most striking example—it will be seen that the shaft consists of a tube, with thick and strong walls, which gradually pass toward either end into a thin shell, filled with a network of cancellous bony tissue, of which more will be said presently. The aggregate of osseous substance is the same throughout; so that an inch of the length, taken from the middle of the shaft of the femur, will weigh about the same as an inch of the length cut near either end. Sections of the pelvis and scapula will show a very analogous arrangement between their flat and their spongy portions; and the same may be said of the vertebræ. In other words, the structure of all bones is adapted to the bearing of either strain or pressure, or both. Where, as in the shafts of the long bones, strain is to be provided for, the material is massed in tubes of adequate thickness of wall; and it will always be found that this thickness is greatest on the concavity of curves. On the other hand, where, as at the articulating ends, pressure is to be sustained, the bony substance is spread out so as to give surface. Allusion was just made to the backing up of the thin shell, thus formed, by reticular tissue; and this deserves special notice.

Everywhere in the spongy bones, as well as in the articular ends of the long bones, the lamellæ forming this network run at right angles to the surface, so as to receive the pressure directly upon their extremities, and thus to

afford the greatest possible strength. Sections, vertical or transverse, of the bodies of the vertebræ, of the astragalus, of the carpal or tarsal bones, or even of the articular ends of the phalanges, will show this law; and it will be further noticed that, in any of these cases, if the surface to receive pressure is concave, the shell of bone is thickened accordingly.¹

If now the lines of muscular traction be considered, the further fact will appear that it is invariably exerted so as to bear in the *length* of these columns of bony tissue, whether of the shafts or of the extremities of the long bones, or of the mass of those more or less cubical in shape. The ribs, pulled upon by the intercostal muscles at their upper and lower margins, are filled from end to end with cancellous tissue, so arranged as to take the strain thus imposed, while other lamellæ, placed transversely, meet the effect of pressure; hence these bones, although long in shape, are analogous to the so-called thick or round bones in structure. In looking at the relations of the ribs to muscles, it must not be forgotten that very powerful strain is brought upon these bones by some of the muscles acting on the upper extremity; but it will be found that in this respect also the same law as to the distribution of stress is carried out, so as to reduce it to a minimum for each portion of each bone.

The lines of tension of the muscles always form more or less acute angles with the axes of strength of the bones acted upon by them; and this rule is more close and definite in proportion to the length and power of the muscular masses concerned.

From what has now been said, it will probably be apparent that the arrangement of the bony material is such as to adequately provide for meeting all the stress to which it is normally exposed. Let it be recalled, however, that each bone is but a member of a mechanical system of levers, and hence that the force brought to bear upon it may be vastly increased, as well as changed in direction, so as to take it at a disadvantage. Under these circumstances, its texture gives way to what is called in mechanics a "cross-breaking strain." The obliquity of most fractures with regard to the long axis of the portion of bone involved, to be presently noticed as almost if not altogether universal, is an additional proof of the correctness of this view.

Now the prevalence of this mechanism, together with the systemic relation of each bone, above recalled, may serve to explain in great degree the existence of the dominant lines of breakage to which reference has been made, and which will be further spoken of in connection with special fractures.

A bone being broken across, it will easily be seen how in very many instances one of its fragments may engage in the other, and act as a wedge to split it into two or more smaller fragments.

The natural curves of the long bones, and the slight twist which is presented by the longitudinal axes of many of them, although of advantage in their normal function, may render their fracture easier under certain circumstances.

Of all these mechanical conditions, instances will present themselves in connection with special fractures; and the general statements now made may suffice for the present.

¹ The reader will find this subject well set forth and illustrated in Wagstaffe's *Student's Guide to Human Osteology*, London, 1875; and by Wyman, *Trans. Am. Med. Assoc.* for 1850. It has been almost wholly overlooked by systematic writers on anatomy.

VARIETIES OF FRACTURE.

A good many terms have from time to time been suggested with a view to the designation of peculiarities presented by these injuries, but only a few are or need be retained. Confusion has arisen from the employment of some of these terms in different senses by different authors; it is therefore especially necessary to define them as they will be used in the following pages. With regard to some of the varieties, the mere definition will suffice; but of others I shall have to speak more at length, and will do so here for the sake of convenience.

SIMPLE AND COMPOUND FRACTURES.—A *simple* fracture is one to which the atmosphere does not find access, the soft parts remaining so far intact as to exclude it. There may be very extensive injury of all the tissues, and the skin not divided; or there may be a gaping wound of the skin, and the muscles and fasciæ untorn; but in either case, the fracture is still a simple one.

When the external air is admitted to the broken portion of bone, whether by the action of the fracturing force wounding the soft parts from without, or by the thrusting of the fragments through the skin, the injury is called a *compound* fracture.

A fracture, at first simple, may become compound by a process of sloughing or ulceration, or by suppuration; and conversely, a fracture, compound either primarily or secondarily, may become simple by the healing of the external wound and the consequent exclusion of the air.

Compound fractures, as would naturally be supposed, vary extremely in severity; but they are always more serious than the same amount of bone-injury would be if not exposed to the air. Sometimes the opening in the skin is but small, yet the bone is very extensively crushed and splintered, and the other soft parts have been torn and bruised beyond repair; sometimes the bone suffers very largely, while the soft parts are very little injured; sometimes the wounding of the tissues about the bone is greatly in excess, the bone itself being merely broken across; and in some cases a formidable laceration of the skin may attend upon comparatively trifling hurts to the deeper soft parts and to the bone itself.

Railroad, machinery, and mining accidents, and falls from heights, are the most frequent causes of compound fractures, which may, however, be produced by much less formidable forces. I have several times seen these injuries, so grave as to require amputation, the result of slight falls. An attempt to rise and walk will sometimes convert a simple fracture of the leg into a compound one, by the ends of the fragments penetrating the skin. Occasionally the seat of fracture is laid bare secondarily by the occurrence of suppuration or by sloughing of the superjacent soft parts; but here the gravity of the condition is not dependent upon the mere exposure of the bone.

Compound fractures are more serious than simple, because they involve as a general thing more severe injury to the bone itself; because in them the tearing of the periosteum, an almost invariable accompaniment of any breaking of the bone, is apt to be greater, whence there is more risk of impairment of nutrition—recovery, as will presently be further shown, being thus hindered, rendered more difficult, or prevented; because the violence done to the surrounding soft parts is greater; and because, independently of any septic influence exerted by the atmosphere, subcutaneous injuries of all kinds are repaired more readily than those which are deprived of the protection of the skin. Suppuration is almost sure to follow upon compound fracture: it

is only in very rare instances that the immediate closure of the wound can be effected.

It is in compound fractures, more frequently than in any other class of injuries, that the question of amputation is raised. For the discussion of the conditions requiring it, the reader is referred to the article on Amputation.¹ The treatment of compound fractures not calling for the removal of the limb, will be considered in connection with that of fractures generally.

Fig. 803.



Comminuted fracture.

MULTIPLE, COMMINUTED, AND IMPACTED FRACTURES.
—When there are two or more distinct breakages, whether of the same bone or of different bones, the case is said to be one of *multiple* fracture.

When there are several fragments, the fracture is said to be *comminuted*. (Fig. 803.) Sometimes there is one main line of breakage, and the end of one or of both fragments is split or shattered into several smaller ones. (See Fig. 804, *d*.)

Impacted fracture is said to exist when one of the fragments penetrates the other, and is so wedged into it as to limit or prevent their mobility upon one another. Usually there is first a partial separation, and then either by external force or by muscular contraction the wall of one fragment is driven into the cancellous structure of the other.

Multiple fractures are generally produced by very great violence, such as railroad or machinery accidents, or falls from heights; forces being exerted either at the same moment, or successively, upon different portions of a limb or of the body. They derive their gravity either from the amount of injury inflicted, and the consequent shock to the system, or from the difficulty involved in the application of proper dressings.

Some years ago a man was brought to the Episcopal Hospital, who, while drunk, had been run over by a “dummy” engine as he was stooping down to hunt for his pipe on the ground. Almost all the bones in his body seemed to be broken, except those of the head; his ribs were smashed; his pelvis ground up so that it felt like a mass of loose stones, and his extremities could be twisted about in any direction. He died about an hour after the alleged time of the accident.

In December, 1881, a colored man, aged 32, was brought to the Episcopal Hospital, having been injured by a derrick falling upon him. He presented but slight symptoms of shock, but died in about two hours. On examination it was found that eight ribs on the left side were broken, and seven on the right; on the left side the pleura was wounded, and the eighth intercostal artery was divided by a spiculum of bone; on the right side four of the ribs had injured the pleura, and two had penetrated the lung also. In each pleural cavity there were a number of spicula of bone. Fractures of the spinous and transverse processes of the second, third, fourth, and fifth lumbar vertebræ, and on the left side division of two lumbar arteries by spicula, causing large hemorrhage into the areolar tissue, were noted. There were also oblique fractures of the right femur in its lower third, and of the left fibula in its upper third, with rupture of the internal lateral ligament of the knee.

Gross² speaks of an old woman, who, by a fall from a third story window, sustained no less than eighty-three fractures.

¹ Vol. I. p. 560.
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² Op. cit., vol. i. p. 898.

Less interest attaches, however, to cases such as those just given (the list of which might be almost indefinitely extended), which are inevitably fatal, than to those in which only two or three fractures are sustained, and in which the treatment presents points of much difficulty.

In April, 1882, a boy, aged 14, was brought to St. Joseph's Hospital, having been carried ten times around a revolving shaft. He had fractures of the right humerus, radius and ulna, and femur, and of the left radius and ulna; also dislocation of the hip and elbow on the right side. There was marked shock; but he ultimately made a good recovery.

I was called, in 1881, by Dr. Downs, of Germantown, to a young man, aged 22, who had had his right arm caught around a shaft, and had sustained fractures of the humerus, radius and ulna, and metacarpus. The swelling of the whole limb and shoulder was so great as to mask the injuries somewhat, and to interfere with the management of the case; but, as it subsided, we succeeded in getting the bones into good position, and an almost perfect restoration of all the functions of the part was effected.

When a part contains two bones, and a fracture of both is caused by the same violence, although at such different levels that the two lesions are quite separate, the case is not said to be one of multiple fracture;¹ nor is the term applied to cases where several ribs are broken, unless the injury should affect both sides, or be not only at different points, but due to forces acting distinctly only on those points. Two or more separate fractures, each requiring special attention in the way of treatment, must exist in order to bring the case properly under the present head.

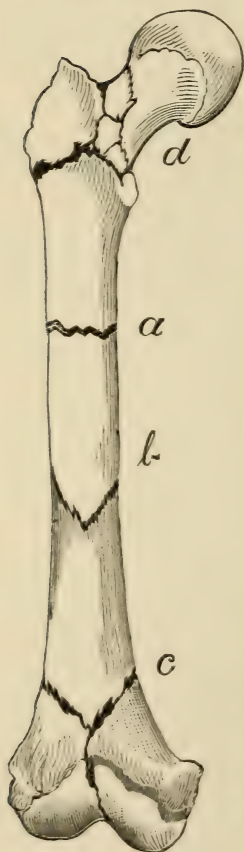
Of course, very various combinations of fractures may present themselves, and must be dealt with according to the best judgment of the surgeon. Some of these combinations will be referred to more in detail in speaking of fractures of special regions.

TRANSVERSE, OBLIQUE, AND LONGITUDINAL FRACTURES.—Fractures are further divided according to their direction, into *transverse*, *oblique*, and *longitudinal*; these terms having reference to the relation of the line of fracture to the longitudinal axis of the portion of bone involved. (Fig. 804; *a*, transverse; *b*, oblique; *c*, mixed oblique and longitudinal.)

Transverse fractures, strictly speaking, are extremely rare. Occasionally they are met with in the succulent bones of the very young, and sometimes as the result of extreme violence. I once saw a thigh-bone broken directly across by the impact of a heavy charge of shot at very close range. But as an almost universal rule, a greater or less amount of obliquity may be looked for in fractures; a fact which has already been alluded to in support of the leverage theory of the mechanism of the production of these injuries.

Longitudinal fractures are also very rare, except as subordinate to other lines of breakage. Fig. 805, copied from Holmes's "System of Surgery," represents

Fig. 804.



Transverse, oblique, and longitudinal fractures.

¹ Non-professional people often say that a man had his leg "broken in two places," when they merely mean that both bones were broken.

a remarkable instance of a tibia split for a considerable portion of its length. Generally, the fractures called longitudinal are merely extremely oblique, so as to be nearly parallel to the axis of the bone. It almost always happens that the fragments are *serrated* along their margins, by the irregularity with which the fibres give way. Sometimes the serrations are fine and close, but oftener the line of fracture is extremely jagged, and presents several strongly marked, tooth-like processes. The proper coaptation of these edges may be very difficult, by reason of their interlocking; but if it be once effected, they serve to prevent the reproduction of the displacement. It will readily be perceived that projecting portions of the fragments are apt to be broken off, and that they may occasionally give rise to much trouble by acting as foreign bodies.

Fig. 805.



Longitudinal fracture of tibia.

VARIETIES OF INCOMPLETE FRACTURE.—So far, reference has been made only to *complete* fractures, in which the whole thickness of the bone is broken through. It remains to say something of *incomplete* fractures—a term which embraces a variety of forms of injury.

Fissures or cracks need hardly be formally defined here. They occur mostly as accessory to complete fractures, from which they branch off, frequently in a spiral course. In the flat bones, and especially in those of the cranium, they are often met with, and may be stellate, radiating, or camedrated. Very rarely, they exist alone in the long bones, as the result of violence not quite sufficient to break the whole thickness of the shaft; in such cases they may be unsuspected until much and long-continued mischief has been caused. Some of the recorded instances will be referred to in connection with the special bones concerned.

Splintered fractures are such as consist in the detachment of a small portion, generally an edge, of a bone, the main body of which is left intact. They are seen occasionally at the brim of the pelvis, or at the spine of the tibia; but for obvious reasons they may readily pass unrecognized unless attended with a wound making them compound.

Perforations of bone are always compound fractures, and almost invariably the result of gunshot injury; the reader is therefore referred, for information concerning them, to the article on Gunshot Wounds.¹

Sprain fractures have been already briefly mentioned under the head of “fractures by avulsion,” as those in which small fragments of bone are pulled away by excessive stress put upon the ligamentous fibres attached to them. Thus Bruce² has published a case in which, by a fall from a second story window, a boy aged 12, had a piece torn out of the right tibia, and one out of the left femur, in each instance by the anterior crucial ligament. And Dittel³ is reported to have met with an instance in which the spine of the tibia was thus wrenched away in a man who was violently kicked in the ham. Cases are referred to as observed by Poncet, and one at the University College Hospital, in London, in a boy aged 11, who had been run over by a cart. Dittel failed to produce this lesion experimentally on the dead subject.

Shepherd⁴ has described a fracture of the portion of the astragalus into

¹ Vol. II. pp. 121 *et seq.*

² Trans. of the Pathological Society of London, vol. xviii. 1867.

³ Med. Times and Gazette, Sept. 30, 1876 (from Centralblatt für Chirurgie).

⁴ Med. News, June 10, 1882.

which the posterior fasciculus of the external lateral ligament of the ankle joint is inserted, which probably belongs in this class. He exhibited four specimens, all however taken from bodies in the dissecting-room, and without history.

Callender, who I believe first gave the name of "sprain-fractures" to these injuries,¹ suggests that the bit of detached bone may remain held by its ligamentous connection, but, failing to unite, may act as a foreign body, occasionally getting caught in the joint. Of this, however, there is no known instance.

I have recently seen a case in which the tip of the inner malleolus was torn off in a fall on the ice; whether it united or not I cannot say, but the injury was followed by very intractable lameness. Very little is as yet known in regard to this form of fracture, to which special attention has only recently been attracted; but the injury to the bone adds to the gravity of the case, renders recovery much slower, and may even cause permanent impairment of the functions of the limb. Such cases, there can be no doubt, have often been unrecognized. Crepitus may sometimes be detected, but may be wanting by reason of effusion into the joint or into the tissues, or because the small fragment is separated from the main portion of the bone.

Any case of sprain or other injury about a joint should be carefully examined with reference to the existence or non-existence of this form of fracture, and its possibility, or proof of its presence, should influence the surgeon in making and expressing a prognosis.

Partial fractures are those in which a bone is so acted upon, either by direct or by indirect violence, that some of its fibres are broken, while the rest are only bent. Sticks are often broken in this way, especially when they are green and tough; hence the name "green-stick"² or "willow" fracture has been given to this form of injury. And fractures of this kind are especially apt to be met with in the tough and resilient bones of the young, in whom, moreover, the periosteum is proportionately thicker and less apt to be torn through than in later life. Otto³ says that he has seen incomplete fracture in the radius of a lion, as also in the bones of animals of the deer kind.

Reference may be best made here to the subject of *bending of bones*, about which there has been much discussion, some surgeons maintaining that it is common, and others that it is impossible. Without going into the history of the question, I may say that cases were long since observed, in which, generally in the forearm, distortion, or rather angular deformity, was noticed, but without any of the other signs of fracture to be presently described. Sometimes, indeed, there was pain, and always more or less loss of power; but not the helpless dangling of the limb usual in fracture. Hence it was claimed that the affected bones were not broken, but only bent. Experience, however, showed that whenever dissections were made in such cases, the lesion was found to be incomplete or partial fracture, as above described. It must be admitted that Hamilton⁴ succeeded in bending experimentally the bones of young animals; but this does not prove the possibility of such a thing in the human subject; and for practical purposes it is better to regard and treat cases of apparent bending as partial fractures. I believe, indeed, that this would be the true view of bending, if that were shown to exist; that is, that

¹ St. Bartholomew's Hospital Reports, vol. vi. 1870.

² "There is also a curvedness which may be reduced to a fracture. I have seen it in children often. . . . It is as it were when you break a green stick; it breaks, but separates not."—Wiseman, "Chirurgical Treatises," vol. ii. book vii. p. 239, 6th ed. 1734.

³ Compendium of Human and Comparative Pathological Anatomy, translated by South. London, 1831.

⁴ Op. cit., p. 85.

the crumpling up of the bony tissue of the wall on the concavity, would amount to a solution of continuity equivalent to the rupture of the bony fibres of the wall on the convexity in the usual form of partial fracture, and that the difference would be simply that in the former case the convex wall, and in the latter the concave, remained unsevered. Such a result is often produced in the attempt to bend metallic tubes, and may have existed in the really tubular bones which were experimented upon by Hamilton, as above mentioned.

Partial or "willow" fractures are generally produced by moderate force, or by great force acting slowly. Thus in many of the recorded cases they have been the result of slight falls; and Hodge¹ and Parkman² have seen them in young men carried around revolving shafts. Farquharson³ published one in a young man of 18, sustained in a foot-ball match. Two very remarkable cases, due to gunshot, were observed during our late war.⁴ They affected the right ninth rib and the left fourth rib, and the patients were aged respectively 21 and 28 years.

The restoration of the shape of the limb is apt to be very difficult, and in its accomplishment the fracture is often rendered complete. Sometimes, however, it has been gradually brought about by nature, apparently as the result of the continuous action of the surrounding muscles.

EPIPHYSEAL SEPARATIONS OR DISJUNCTIONS, met with only in the young, before consolidation by bone has taken place between the diaphyses and the epiphyses, do not differ materially from fractures, although the tissue which gives way is not true bone, but the cartilage-like, osteogenetic matrix. Sometimes in these cases the line of separation seems to be very nearly if not quite transverse. Union generally takes place readily, but the subsequent growth and development of the whole bone has seemed in some instances to have been interfered with.

Hutchinson⁵ gives instances of deficient growth in bones which have been the seat of such injuries, and Holmes⁶ says that he has several times noted this after fractures in the neighborhood of the wrist. In all cases the child's friends should be informed of the probability of impaired development as a result. Holmes, from a study of the specimens contained in the Museum of St. George's Hospital, is inclined to agree with some of the French surgeons⁷ in the opinion that "the line of fracture seldom runs accurately through the epiphyseal cartilage in its whole course."

I shall have occasion to refer to these injuries again in speaking of ordinary fractures affecting special bones in the neighborhood of their articular extremities.

COMPLICATED FRACTURES.—This term has a special significance in surgery. According to ordinary speech, any coincident condition, such as delirium tremens, tetanus, or disease of the liver or kidney—rendering the treatment more difficult and the prognosis more grave—might be said to complicate a fracture; and so also would the existence of other fractures or injuries, even in distant regions of the body. But, in surgical language, a *complicated* frac-

¹ Proceedings of the Pathological Society of Philadelphia, vol. i. p. 232.

² Am. Journal of Med. Sciences, Oct. 1853.

³ British Med. Journal, Dec. 4, 1869.

⁴ Med. and Surg. History of the War of the Rebellion. First Surgical Volume, pp. 567 and 568.

⁵ Transactions of the Pathological Society of London, vols. xiii. and xvii.

⁶ Surgical Treatment of the Diseases of Infancy and Childhood, 1868, p. 240.

⁷ Gazette des Hôpitaux, 1865.

ture is one along with which there is some serious surgical lesion of neighboring structures.

Thus there may be extensive wounding of the soft parts, but not admitting the air to the broken ends. (Such admission of air would, as before said, make the fracture *compound*; and while the fact of its being compound really constitutes a complication, there is a propriety, as well as convenience, in limiting the use of these terms.)

Again, the original violence may have not only broken the bone, but also ruptured the adjacent artery or a vein of considerable size, or lacerated a large nerve-trunk. Such rupture or laceration may also be caused by contact with the sharp or jagged edge of one of the fragments.

Or, besides the fracture, there may be luxation of the neighboring joint; or, without dislocation, the joint may have been seriously damaged.

Or, in certain positions, important viscera may have been lacerated or penetrated by the fragments; thus the bladder is apt to be ruptured in fractures of the pelvis, and the lungs, or even the heart, may be wounded in fractures of the ribs.

The amount and character of the influence exerted by these other lesions upon the course of a case of fracture, vary, as might be supposed, very greatly. Some, as wounds of the soft parts, merely embarrass the surgeon in his treatment; others, like luxations, require special measures for their relief; or, if uncorrected, will, in a marked degree, vitiate the ultimate usefulness of the limb. Injuries of vessels or nerves, superadded to fracture, may necessitate amputation.

But there is a large class of complicated fractures—those in which the viscera are wounded—in which the gravity of the complication is apt to be such as to altogether overshadow that of the fracture. These cases may be amenable to surgical treatment, as, for example, when the bladder is ruptured in fracture of the pelvis, and success depends upon preventing the escape of urine, either into the surrounding areolar tissue or into the peritoneal cavity; or they may come within the province of the physician, as when a pleurisy is set up by a broken rib. Sometimes the lesion complicating the fracture is necessarily fatal, as in the case of a wound of the heart.

Further reference to these various complications will be made in connection with fractures affecting special bones.

There is still another class of complications of fracture—those, namely, which arise secondarily, from the occurrence of inflammation in neighboring parts. Thus it occasionally, though rarely, happens that an abscess is formed either about the fragments, in the soft parts close by, or in a joint. Under such circumstances, the treatment of the fracture itself may be seriously interfered with, and the prospect of restoration of usefulness to the limb much impaired.

INTRA-UTERINE FRACTURES.—Notwithstanding the mobility of the fœtus, and its protection by the amniotic liquid and by the maternal body, its bones are occasionally broken. These injuries are generally due either to blows or to other violence inflicted from without through the belly of the mother, or to abnormal contraction of the muscles of the child itself. In one or two instances, one of twins has sustained fracture apparently from entanglement of its limbs with those of its fellow.

When external violence is the cause of these fractures, the effect is, of course, limited to those bones on which it falls. Of this many instances have been published, and are quoted by Malgaigne and other systematic writers. Only a few points need be noted here.

Sometimes union has already taken place at the time of birth; as in the case reported by De Luna.¹ A woman aged 32, at the middle of the ninth month of pregnancy, fell down stairs, striking her belly against a wooden tub. Pain, not very severe, and faintness followed. The child, when seen by the reporter, was four weeks old, and had "fracture of the clavicle near the acromial extremity, united by bony callus, with considerable overlapping."

In one case recorded by Rodrigue,² the humerus was dislocated, and both bones of the forearm of the same side were broken and firmly united at an angle of about 45°.

Sometimes the fragments have projected, and have been felt by the mother irritating the walls of the womb.

Although the bones in many instances have become solidly united before birth, it occasionally happens that no union takes place. Thus, a case is recorded by Mr. H. Smith³ in which the tibia and fibula, broken within the womb, were still ununited when the child was seven years old. One curious instance is quoted by Gurlt,⁴ from Maeder, in which a woman seven months pregnant fell from the top of a ladder, and subsequently lost, at first blood, afterward blood and water, from the vagina; she had also persistent pains in the belly, but no loss of general health, and her confinement was normal. Her child, a strong boy, was born wanting the left upper extremity from the middle of the arm, where the white bone protruded through a reddish-brown, moist, but not bleeding or suppurating wound, which soon healed up. The separated limb came away with the after-birth; it seemed to have undergone maceration. This case, which stands alone, as far as I can ascertain, admits of only one explanation, which suggests itself.

It is scarcely worth while to dwell here upon the cases in which very numerous fractures have been seen in the fœtus, as in most of them there is no question that they were the result of diseased conditions of the skeleton, and it is probable that this was the true explanation in all. Sometimes it is clearly from deficient ossification between the diaphyses and epiphyses.

Thus, Barker⁵ reported a case in which all the long bones of the extremities were broken, and the frontal, parietal, upper part of the occipital, and squamous portion of the temporal were absent. On examination, the skeleton was found deficient in inorganic matter, except in certain enlarged portions which contained an excess.

Brodhurst,⁶ in a paper read before the Royal Medico-Chirurgical Society, suggested the connection between these lesions and other congenital defects, such as distortions of the feet and hands. In the discussion which followed, Messrs. Little and Pollock spoke of cases which they had seen with deficiencies of fingers and toes; and Mr. Adams said that the limbs in such cases did not grow normally.

Davies⁷ has reported a case in which a man, grown up when seen by him, had had an intra-uterine fracture of the leg, in which this defect of growth was very marked.

Of *fractures sustained during birth*, very little need be said. They are sometimes caused by the powerful expulsive contractions of the uterus; as in a case reported by Vanderveer.⁸ But they are for the most part due to the

¹ Am. Journal of the Med. Sciences, July, 1873.

² Am. Journal of the Med. Sciences, January, 1854.

³ Trans. of the Pathological Society of London, vol. xviii. 1867.

⁴ Op. cit., Bd. i. S. 222.

⁵ British Medical Journal, Sept. 26, 1857.

⁶ Med. Times and Gazette, April 7, 1860; Med.-Chir. Transactions, vol. xliii.

⁷ British Medical Journal, Oct. 17, 1857.

⁸ Am. Journal of the Med. Sciences, May, 1847.

operations of the accoucheur. Gibson¹ says that he has seen the clavicle give way from an ignorant midwife pulling at the arm. Malgaigne mentions a number of cases of epiphyseal disjunctions thus produced; in one, the lower epiphysis of the femur and the upper epiphysis of the tibia were separated at the same time by traction on the foot. In the use of the blunt hook such accidents sometimes occur, and cannot always be avoided even by the most dexterous and careful operators.²

PHENOMENA AND SYMPTOMS OF FRACTURE.

When a bone is broken, it loses more or less completely its value as a lever, and the muscles of the part, instead of acting upon it as a whole, act upon the fragments separately. The periosteum is torn, or, in rare cases, stretched. The surrounding soft parts, including capillary and other vessels and nerve fibres, are ruptured and lacerated to a greater or less degree, and pressed upon by the ends, jagged or pointed, of the fragments. Hence, the injury gives rise to a series of phenomena, or symptoms, which are now to be described.

SOUND.—Occasionally, but very rarely, the patient hears a distinct *sound* attending the giving way of a bone; and sometimes it is even perceived by the bystanders. But under the circumstances of excitement usually attending an accident, a momentary and unlooked-for noise may readily escape notice, even if it were one which would, if expected, be plainly audible.

LOSS OF FUNCTION.—Almost always there is immediate *loss of power* in the part where the fracture is situated. This does not mean that the muscles are paralyzed, although we often hear non-professional persons assert that an arm, for instance, cannot be broken, because the patient can move his fingers. But the value of the affected bone, as a lever, is destroyed; and hence the system of which it forms a part is useless.

When, however, there are two bones, only one of which is broken, or when the injured bone is braced by tissues around it, there is sometimes so little disability, for a time at least, as to cast doubt upon the reality of the fracture. Thus, Hunt³ records the case of a man aged 26, struck by a falling girder, who walked next morning to a steam-train, got off at Philadelphia, and into a street-car at the station; from the car he walked with a stick some two hundred and fifty yards to the Pennsylvania Hospital gate, and thence up into the ward in the third story. He died on the twenty-third day, from pelvic abscess and pyæmia, and it was found that "the neck of the femur, immediately behind the head, was broken directly across; the line of fracture being immediately within the capsule of the joint."

In 1877, I saw an elderly lady who broke the neck of the femur by tripping in the carpet, and who yet walked up and down a flight of stairs several times a day during the following week. She died exhausted about two weeks subsequently, and there was found extensive fracture of the bone referred to.

¹ Op. cit., vol. i. p. 255.

² The reader, should he wish to pursue this subject further, will find valuable information in Bouchut's *Traité Pratique des Maladies des Nouveaux-Nés*, etc., Paris; also, in Delore's article on Fractures in the Fœtus, in the *Dictionnaire Encyclopédique des Sciences Médicales*; in Kuestner, *Die typischen Verletzungen des Extrem.-knochen des Kindes durch den Gebärtshelfen*, Halle, 1877. He may also consult with advantage an article by Dr. Alex. Russell Simpson, "On Diastases in the Bones of the Lower Extremity of the Fœtus, produced by the Accoucheur," in the *Edinburgh Med. Journal* for June, 1880; and one by Ruge, in the *Zeitschrift für Gebärtsh. und Frauenkrankheiten*, Berlin, 1876.

³ Philadelphia Medical Times, Oct. 26, 1872.

In 1876, one of my own children had his arm broken by an accidental blow; there was no displacement, and no sign of fracture except pain and loss of power, until two weeks later, when he had a fall, and the fragments at once became freely movable.

DEFORMITY of the affected part is almost always one of the results of fracture; not invariably, because it may be that the periosteum remains sufficiently intact to hold the fragments in place. The kind and degree of deformity vary greatly in different bones, and in different portions of the same bone; it is apt to be less where the fracturing force has not been very violent, where only one of two parallel bones is broken, and where the bone, if single, is surrounded by a large mass of muscle.

Deformity may be owing either to the original violence, to muscular contraction, to the weight of the distal part of the limb, or to incidental causes, such as, in case of the femur, the pressure of the bed-clothes on the foot. When the fracturing violence is direct, it simply forces the fragments apart after breaking them; and they may be held thus by the entanglement of their serrations, by muscular contraction, or by both combined; when it is indirect, the leverage afforded by one or both fragments will be readily understood. Muscular contraction may drag the fragments apart, as in the case of the patella or olecranon; or may pull one fragment past the other, as when the shaft of the femur is broken obliquely; or may rotate one fragment, as in fracture of the cervix femoris. In case of fracture of the thigh or leg, the slight weight of the foot, perhaps with the addition of that of the bed-clothes, is sufficient, acting through a long bent lever, such as is formed by the distal part of the limb, to produce great twisting.

We often meet with expressions such as "the fragments being uncontrolled," and "the fragments assuming bad positions;" but these are incorrect, as they imply that the fragments are not, as they really are, absolutely passive. It is not generally at the seat of injury that we must look for the causes of deformity or of its continuance.

However produced, deformity consists in a change in the relation of the axes of the fragments. This change may consist either in their forming an angle with each other—angular deformity; or in the rotation of the distal one—rotary deformity; or in the end of one passing by the end of the other—lateral deformity, over-riding, over-lapping, or shortening. Obviously these may all be presented together in fracture of a long bone—the femur, for example—or they may exist singly. And either of them may, in either case, be very slight or very pronounced; but their significance does not depend upon their degree.

Of all the phenomena attending fractures, the deformity is the most important, not as much on account of appearances (although in women this may sometimes be a matter of great moment), as by reason of the disability which it is apt to involve if it is uncorrected. Even a slight degree of angular or rotary displacement may, in the upper extremity, interfere seriously with the complicated movements upon which the free use of the hand depends, or, in the lower extremity, may give rise to awkward lameness. Hence the great end and aim of the innumerable appliances which have been, constantly are, and probably will always continue to be, proposed for the treatment of fractures, is the keeping of the fragments in their normal relation until they have become fixed thus by the process of repair.

The degree of the deformity is not always, or indeed generally, an index of the difficulty of its correction; for often a very slight displacement can scarcely be overcome, while it may be that a very great one will yield at once. But, on the other hand, deformity which is easily corrected is apt to

be reproduced with equal readiness, and under such circumstances all the resources of the surgeon may be taxed to keep the fragments in proper place.

A point which should always be borne in mind, is that the pain suffered by the patient may be very slight, although the bones are in very bad position. Hence the surgeon should by no means be satisfied that all is going on well because no complaint is made. Nothing but actual inspection of the injured part can assure him of its safety. This remark, however, does not apply to fractures of the ribs, or to such other fractures as are serious only because of the involvement of contained viscera.

PAIN is an almost invariable attendant upon fracture. It is due in part to the tearing of the soft parts, and to the inflammatory condition immediately set up thereby; in part to the irritation of the soft parts by the ends of the fragments; and perhaps in part to the sensitiveness of the fragments themselves, or at least of the medulla. A peculiar, thrilling, numb pain, extending down along the limb to the fingers, is often complained of in fracture of the arm, from pressure of the lower end of the upper fragment against the nerve-trunks; and occasionally, but much more rarely, an analogous pain accompanies fracture of the leg.

I have once or twice seen cases in which the persistent pain was out of all proportion to the severity of the injury, in persons of very sensitive nervous systems, and liable previously to attacks of neuralgia; but generally the pain is not very violent, and subsides steadily with the reduction of inflammation. It is only apt to remain, under proper treatment, when the fracture is in a part such as the lower third of the forearm, where there are extensive thecal serous membranes; here there may be set up a sort of rheumatoid irritation, difficult to overcome, and productive of much suffering.

A notion prevails extensively among the laity that fractures are most painful when they are "knitting," and that the ninth day is the time when this process is at its acme; I need hardly say that this opinion is wholly without foundation in fact.

Persistent pain, or rather tenderness, over one part of a bone may become an important symptom in case of mere fissure.

MOBILITY.—A greater or less degree of *mobility* at the seat of fracture is nearly always observable, and is more distinct the nearer the lesion is to the middle of a long bone. Of course the mobility referred to is passive, and may be detected either upon an attempt of the patient to use the part, or by grasping the two portions of the limb, one in each hand, and then placing them at an angle with one another, or rotating them in contrary directions. It is upon this mobility that the loss of power after fractures is chiefly dependent.

CREPITUS.—Along with the mobility, if the ends of the fragments be in contact, there is developed a peculiar, rough, crackling or clicking sound, partly heard and partly felt, known as *crepitus* or *crepitation*. It is not always equally distinct, being sometimes masked, either by effusion of liquid or by the entanglement of soft parts between the fragments, sometimes lessened by impaction. It is not present, for obvious reasons, in incomplete fractures. *Bony crepitus* should be carefully distinguished from what is known as *soft crepitus*—the crackling of dry tendon-sheaths—and from a very similar but smoother sound due to the rubbing of the dislocated head of a bone over the surface of another bone covered by periosteum. When clearly heard and felt, true crepitus is proof positive of fracture. Yet it does not always indicate accurately the degree of mobility. It may be quite loud,

and give the impression of loose grating, and yet the fragments may be closely held together. I recently saw an instance of this in an old lady of eighty-five, who died some weeks after sustaining a fracture of the cervix femoris; during life and after death, the crepitus was so distinct as to lead to the belief that the fragments were very movable, yet, when the bone was removed they were found in accurate apposition, and hardly any sound could be elicited.

Crepitus is of course wanting when the fragments are not in contact, as in fractures of the patella and olecranon, if one portion of the bone is drawn up so as to leave a wide gap, and in some cases of overlapping.

I feel constrained here to enter a protest against the employment of undue efforts to obtain crepitus. Should it not be readily felt, the surgeon should fall back upon the other means of diagnosis; as by persisting in the attempt to move the fragments upon one another, he not only gives present pain to the patient, but may do harm by producing or increasing displacement. When once the surgeon in charge has perceived it, he ought not to unnecessarily elicit it, again and again, as I have sometimes seen done, to satisfy either himself or others.

SWELLING is very apt to follow upon the occurrence of fracture, especially in superficial bones, and in the neighborhood of joints. It is due to inflammatory effusion, and takes place very rapidly, sometimes almost immediately.

ECCHYMOSIS nearly always shows itself in the vicinity of a fracture, and is often owing to the rupture of small vessels in the soft parts, just as in any other bruise. But when a bone is broken, its vascular medulla is torn across; and hence there comes on gradually an extravasation of blood, sometimes staining the skin a deep mottled purple, almost black, and extending along the limb for a great distance. This secondary effusion of blood is much more significant than that which shows itself within the first few hours after the injury. It is usually very slowly absorbed, and may often be still perceptible as a green and yellow discoloration, even after the fracture has been altogether repaired.

At the same time with this extravasation, there may appear upon the surface of the skin, especially in weakly patients, *blebs* or *bullæ* of various size, sometimes very large, distended with serum more or less stained with blood. These are often a source of great alarm to the patient, and even to the inexperienced surgeon; but if carefully let alone, they will shrink away in time, and the cuticle either becomes re-attached, or a new cuticle forms before the old one is cast off. It is a bad practice to open them, as they may then give rise to troublesome and intractable sores, interfering with the treatment of the fracture itself.

NUTRITIVE CHANGES.—Certain local, atrophic changes have been observed in cases of fracture, and may be mentioned among the phenomena attending injuries of this class, although they are by no means constant. Curling¹ speaks of *atrophy of one fragment* as not uncommon, and gives a list of twenty-four specimens illustrating this condition, which, however, is certainly not often present in such a degree as to attract attention. Guenther² claimed that the *growth of the nails* on the affected limb was arrested during the process of union; but his observation has not been substantiated by the experience of others. I have myself reported³ two cases, one in the leg and one

¹ Med.-Chir. Transactions, vol. xx.

² Gazette des Hôpitaux, Nov. 24, 1842. (Malgaigne.)

³ Am. Journal of the Med. Sciences, April, 1874.

in the ring-finger, in which the nails did not grow on the injured members; but, in spite of careful watching for other similar cases, I have failed to meet with them. *Muscular wasting*, from confinement and disease, is very frequently seen in fractured limbs; but in general it speedily disappears upon the resumption of the normal functions of the part, as does also the œdema which often accompanies it.

From what has now been said of the general phenomena attending fractures, the symptoms may be readily learned. These are divided into two classes,—the *rational*, and the *physical* or *sensible*.

The former are such as give rise to a reasonable suspicion of the existence of fracture; they are pain, loss of power, swelling, and ecchymosis. To these may be added, when it is present, the audible crack caused by the snapping of the bone; but this would not be conclusive, because very much the same sound might accompany the rupture of tendon, muscle, or ligament.

The physical or sensible signs are conclusive: deformity, preternatural mobility, and crepitus. Sometimes the first named, striking the eye of the surgeon, will at once reveal the nature of the case. But for the most part it is from the combination of all that he is enabled to frame his opinion.

CONSTITUTIONAL SYMPTOMS ACCOMPANYING FRACTURE.

Perhaps it will have been noticed that nothing has as yet been said about the *constitutional symptoms* attending fracture. In very many cases these are very slight, and might readily be overlooked by an inattentive observer. Yet they always occur, and are in proportion to the severity of the local injury; modified, however, by the idiosyncrasies of the patients, by their condition at the time of sustaining the hurt, and by incidental circumstances. Thus, in some individuals, the nervous system is very sensitive, and even a simple fracture, produced by slight violence, may give rise to marked *shock*. Such shock may be the more severe from the fact of previous fatigue, of fright at the time of the accident, or from other transient circumstances. Wagstaffe,¹ in an article on temperature in shock, in surgical cases, notes a decided lowering as attendant upon compound fractures; and it is probable that a proportionate degree of reduction would be detected in less serious cases by careful observation.

Following upon this state of depression, a more or less decided *febrile rise* is often noted, especially in private practice, where patients are apt to demand and receive more attention than in hospitals. But Stickler² has proved, by a series of carefully tabulated observations, that there is, as a rule, a temporary febrile rise after fractures; it reaches its maximum during the first three days, when the local inflammation is at its height.

Upon the subsidence of this febrile movement, the system at large generally ceases to manifest any disturbance, and the whole period of local repair may be passed through without any other trouble than perhaps constipation, and it may be indigestion, if the patient is prevented from taking exercise, and yet indulges his appetite. But in old and feeble persons, the powers may be unequal to the tax upon them, and a condition of *debility* may ensue, from which recovery is impossible. I have seen a simple fracture of the humerus prove fatal on the seventh day, in a lady of eighty-one; yet Henderson³ has recorded the case of a woman, eighty-nine years old, whose femur,

¹ St. Thomas's Hosp. Reports, 1870.

² New York Med. Record, Feb. 11, 1882.

³ London Med. Gazette, Jan. 13, 1843.

broken near the middle, was found firmly united on the forty-fourth day; Meachem¹ one, in which, in a woman of ninety, a fracture of the lower third of the leg was united in twenty-eight days; and Lee² one of union of a fractured femur in a man of ninety-eight. These cases are exceptional, and do not set aside the fact that old age makes every injury more formidable.

DIAGNOSIS OF FRACTURE.

This matter has, of course, been to a certain degree dealt with in speaking of the symptoms of these injuries, and it must be considered again in reference to each special fracture; but there are some general points which may be made here, and some rules laid down, in order to save repetition.

The earlier an examination can be made to determine whether or not fracture exist, and its seat, if present, the better; since swelling often comes on very rapidly, and the muscles become rigid, so as to mask the condition of the bone. Hence, if the surgeon be called to a patient who must be moved a long distance to his home, or to a hospital, he should, if possible, ascertain at once the character of the injury, by as careful an examination as the circumstances will allow.

In cases of injury in the neighborhood of joints, this rule is especially imperative; since here the question is apt to be between fracture and luxation, and, if the latter be overlooked, the delay involved may add seriously to the difficulty of reduction. Of mistakes of this kind, instances will be given hereafter.

As a general rule, in the comparison of fractures and luxations, it will be found that, in the former class of injuries, the degree of possible passive motion is increased beyond the normal, while in the latter it is, in certain directions at least, materially diminished. On the other hand, in luxation, the power of moving the limb to some extent is apt to be retained, the lever affected not being broken, but having merely changed its bearing point; while in fractures, as before stated, the limb is usually altogether disabled.

From the study of normal anatomy certain *test lines* have been derived, by which the displacement consequent upon fractures, as well as luxations, may be detected. With these lines, and with the relation of the normal skeleton to them, the surgeon ought to render himself perfectly familiar, so that they may serve as landmarks in his examination of injured parts. They will be detailed in speaking of fractures in the several regions.

The diagnosis of fracture has reference not merely to its existence, but also to its exact seat and direction. The latter points are, indeed, in many cases by far the most difficult to determine, and may have to be arrived at by exclusion only. The general symptoms already detailed may be clear enough, and the fact of fracture be absolutely established, yet the surgeon may be in doubt as to the precise line of breakage, or even, when a joint is involved, as to which of the bones entering into it has suffered. These questions can only be settled by careful exploration, with a skill acquired by experience; in other words, with the educated hand. Occasionally, the observation of the effect of certain passive motions will go far to solve the doubt; or gentle and dexterous pressure with the tips of the fingers, perhaps with the nail, may reveal the line of breakage.

In the *diagnosis of compound fracture*, as to its extent and severity, the finger is always better than any other probe; but even this should be used

¹ Am. Med. Times, 1861.

² St. George's Hospital Reports, vol. iv. 1869.

with caution, and only for the purpose of determining such points as the surgeon really needs to know. All poking about to satisfy mere curiosity, at the risk of disturbing or tearing tissues not already damaged, and all wrenching of the fragments to get at the deeper parts of the wound, should be abstained from. The amount of injury to vessels and nerves can be better ascertained in other ways, and may be increased by meddling and indiscreet handling.

CONSEQUENCES OF FRACTURE.

While it is quite true that, in general, simple fractures progress steadily toward recovery, it is also true that they sometimes give rise to very grave and even fatal symptoms. These symptoms may be general or local, immediate or remote. Murray¹ mentions a case in which a simple comminuted fracture of the thigh was followed by *traumatic delirium*; Hammick,² one in which *tetanus* ensued upon simple fracture of the thigh. *Pyæmia*, not a very uncommon sequence of compound fracture, has been seen by Hewett³ as the result of simple fracture of the leg.

The occurrence of *wounds of arteries, veins, and nerves*, has been already mentioned (*complicated fractures*), and will be again referred to in connection with fractures of special bones. Occasionally, when vessels of some size are injured, *gangrene* comes on, or the *hemorrhage* challenges immediate attention, and either ligation or amputation must be performed; but sometimes the symptoms are only perceived at a later period, when *aneurism*, true or false, has developed itself.⁴ With regard to *nerves* also, the signs of the lesion may appear immediately, or may be postponed until they show themselves in the altered nutrition or sensation of the distal parts. In several instances to be hereafter quoted, it was to the callus that the trouble was to be attributed, either from exuberance of this formation, or from entanglement of nerve-trunks within it. Nerves may also be caught and pinched between the fragments; a case is mentioned by Callender⁵ in which the ulnar nerve was thus entangled in a fracture separating the styloid process and triangular ligament from the rest of the ulna. The same author saw a case in which a compound fracture at the wrist was followed by gangrene by reason of stretching of the ulnar and median nerves.

Pre-existing disease may become fatal when complicated with fracture; thus Hunt⁶ has placed upon record a case in which a man, aged 29, who from the age of four years had had chorea and partial hemiplegia, lost his life from the incessant movement of his arm, broken by an accident.

There are some instances in which untoward results take place without any apparent reason. In one of his clinical lectures, Prof. Verneuil referred to the case of a man, 60 years of age, strong, robust, and tall, who had been in hospital for two months and a half for a fracture of both bones of the leg. He was treated as usual, had exhibited no bad symptoms whatever, and, in fact, was just about to be sent to a convalescent hospital prior to dismissal, when (the only thing that had excited attention having been some alteration in his features) he suddenly died, his face having a violaceous aspect. Prof. Verneuil believed that this must have occurred from *embolism*, which is not very rare after fracture. It is produced by *thrombosis* of some of the veins

¹ Edinb. Med. Journ., Feb. 1882.

² Lancet, 1867, vol. i. p. 628.

³ For much valuable information on this subject, with details of 27 cases, the reader is referred to a pamphlet entitled "Des Anévrysmes compliquant les Fractures. Par Gérard Laurent, Docteur en Médecine, etc." Paris, 1875.

⁴ St. Bartholomew's Hosp. Reports, 1870.

⁵ On Amputations, Fractures, etc., p. 74.

⁶ Pennsylvania Hosp. Reports, vol. ii. 1869.

in the vicinity of the fractured bone, which is the cause of the œdema that so commonly accompanies fracture of the leg. Through a sudden movement or muscular effort, one of the clots which have thus formed in the inferior veins, and which are not usually very adherent, may become detached, and, entering the femoral and iliac veins, and eventually reaching and obstructing one or more of the branches of the pulmonary artery, may give rise to sudden death, as in asphyxia. However, in this case the diagnosis was erroneous, for the most careful examination of all the veins and of the pulmonary arteries failed to show the existence of any clot. The heart was absolutely empty, and the brain, minutely examined, exhibited no disease.¹ Again, Hammick² describes the case of a man with simple fracture of the leg, who was very despondent; on the third morning he "became ill, grew very feeble, and in four hours was dead. We examined with the minutest dissection every part of the body, but were not able to detect anything in the remotest degree to account for his death." It seems not improbable that this may have been an instance of *fat embolism*.

THROMBOSIS AND EMBOLISM.—These sometimes ensue upon the breaking of a bone. Southam³ has recorded two cases, one in a man aged 60, with Pott's fracture of the fibula, in whom thrombosis appeared on the 17th day, and proved fatal, and the other in a woman aged 65, also with fracture of the fibula, who had like symptoms on the 16th day, and died. In the former case the diagnosis was verified by an autopsy. A case is reported by Tyrrell,⁴ in which a man aged 49, had his left leg fractured for the sixth time, the other leg having been broken once. On the twelfth day he had symptoms of cerebral disturbance, followed by partial paralysis of motion on the left side of the face and in the left arm. These symptoms were ascribed by Tyrrell to the withdrawal of his accustomed stimulus, but should rather, perhaps, be referred to embolism.

FAT-EMBOLISM⁵ is a condition first observed as a sequence of fracture by Wagner and Zenker, in 1862. It consists essentially in the passage into the veins of liquefied fat, which is carried into the lungs, brain, and spinal cord, blocking up the capillaries of those organs.

The occurrence of free oil in the blood had been pointed out by R. W. Smith, as early as 1836;⁶ and in 1856 a case was reported by Macgibbon,⁷ in which a woman, aged 35, affected with delirium tremens, died suddenly, the immediate symptoms having been dyspnoea, with coma and marked pallor; the autopsy disclosed fatty degeneration of the heart and other organs, and a great deal of free oil in the blood. Wagner, in 1865, Busch, in 1866, Bergmann, in 1873,⁸ and Czerny, in 1875,⁹ made important investigations on the subject, which has been further studied by Scriba.¹⁰ Flournoy, in 1878,¹¹ showed that three conditions were needful for the development of fatty embolism after fractures: large openings in the veins; free fluid fat; and a *vis*

¹ Med. Times and Gaz., Oct. 22, 1881, p. 486; from Gaz. des Hôpitaux, No. 86.

² Op. cit., p. 74.

³ Lancet, March 1, 1879.

⁴ St. Thomas's Hospital Reports, vol. i. 1836.

⁵ See also the article on Shock, Vol. II. p. 268.

⁶ Stokes, The Diseases of the Heart and the Aorta, p. 308. Dublin, 1854.

⁷ Am. Journal of the Med. Sciences, Jan. 1856.

⁸ Berliner klin. Wochenschr., Aug. 18, 1873.

⁹ Ibid., Nov. 1 und 8, 1875.

¹⁰ See London Med. Record, Oct. 22, 1873; Med. Times and Gazette, Jan. 8, 1876, and British Med. Journal, May 22, 1880. These articles were reproduced in the Am. Journal of the Med. Sciences, Jan. 1874, and July, 1880.

¹¹ Contrib. à l'étude de l'embolie graisseuse. Strasbourg, 1878.

a tergo, generally found in a copious extravasation of blood. Drs. Saundby and Barling, in a recent article,¹ quote papers by Boettcher and D. J. Hamilton, in 1877, Déjérine, in 1878-9, Duret, Sinclair, and Jolly, in 1879, and Mansell-Moullin, in 1881. Déjérine is said to have seen ten cases, and to have produced fat-embolism experimentally upon animals by means of sponge-tents or laminaria-tents introduced into the bones. Sinclair is quoted as authority for the statement that fatty embola were found in 10 per cent. of the bodies examined at the Pathological Institute at Strasbourg; but it should be remembered that post-mortem clots containing fat-globules may readily be mistaken for true fatty embola. The former have been repeatedly met with in autopsies upon diabetics with "milky blood."

Symptoms of Fat-embolism.—From the accounts given by Scriba and others, who have had opportunities of studying this subject clinically, it would seem that fat-embolism comes on as a sort of secondary shock, within two or three days of the receipt of the fracture, and therefore earlier than venous thrombosis usually appears. Its onset is marked by transient attacks of dyspnoea, with irregular action of the heart, slight hæmoptysis, and at first shallow respiration, at times interrupted by deep sighing inspirations; subsequently the peculiar form of breathing known as "Cheyne-Stokes" respiration,² manifests itself. Collapse, with marked pallor of the skin and mucous membranes, soon ensues; spasms of various kinds, or paralyses, generally bilateral, and diminution of reflex irritability, have been noted. The chest is free from dulness or râles. Fat has been detected occasionally in the urine. As to the temperature in this disorder, the accounts of observers vary. According to Scriba, it is lowered; but Skirving³ records a case in which it was at first noted at 100°, but increased to 104°, and after death reached 105°. In another case seen by Saundby and Barling, in 1881, the temperature was 101.8°.

Secondary abscesses do not form in fat-embolism.

Czerny thinks that this condition is a constant attendant upon cases of fracture, but mostly in very slight degree, and without inducing any distinct symptoms. Minich⁴ says that it occurs in all cases of fracture except in children, who are exempt from it by reason of the small amount of fat contained in their skeletons. Scriba is of opinion that it may go through several cycles, and that its injurious effect is due solely to the blocking of the vessels of the brain, since this was observed in all the fatal cases. Minich shares this view as to the cause of death; but it seems as if the interference with the function of the lungs must be at least contributory, if it has not a large share, in inducing the fatal result.

The *diagnosis* of this pathological condition can hardly be very obscure in any case in which the symptoms as described are well pronounced; and the prognosis, under such circumstances, must obviously be extremely grave.

As to the *treatment* of this affection, the intra-venous injection of sulphuric ether would seem to be clearly indicated; and diffusible stimulants might be given by the mouth. I am not aware, however, that any definite line of medication has yet been pointed out.

STIFFENING OF NEIGHBORING JOINTS is a very common sequence of fractures, and may be attributed to various causes. In some cases, violence is inflicted

¹ Journal of Anat. and Physiology, July, 1882.

² "It consists in the occurrence of a series of inspirations increasing to a maximum, and then declining in force and length, until a state of apparent apnoea is established. In this condition the patient may remain for such a length of time as to make his attendants believe that he is dead, when a low inspiration, followed by one more decided, marks the commencement of a new ascending and then descending series of inspirations." (Stokes, op. cit., p. 324.)

³ Lancet, Oct. 7, 1882.

⁴ Lo Sperimentale, Marzo ed Aprile, 1882 (quoted in Medical News, Nov. 11).

upon the joints as well as upon the bone at the time of the accident, and arthritis is set up, with effusion into the periarticular tissues. Or the circulation in the limb or its innervation, may be disturbed, so that the nutrition of all the tissues is impaired, and the movement of the joints is thus interfered with. By some authors, the long-continued immobilization of the joints required by treatment is thought to render them stiff; but this idea is rendered untenable by the fact that experience in other cases gives no such result; and it is more likely that ill-advised pressure by apparatus, or the inflammatory condition above alluded to, is at fault. As a general rule, this stiffening is only transient, and either gradually disappears with use, or yields to proper local medication.

ATROPHY of a broken limb sometimes takes place, and may affect all its tissues, or the bone only. A very curious instance of the latter kind is recorded by Drs. Jackson and Dwight,¹ in which a humerus, broken for the second time, was almost wholly absorbed; and another by Gross,² in which the fracture was originally double. In both these cases the arm retained very considerable muscular power.

When all the tissues of the limb are atrophied, the bone also may shrink, but this is not apt to be the case. The muscles become small, stiff, and weak, and the foot or hand, as the case may be, contracted and twisted, much as in cases of paralysis from lesions of the central nervous system. "Pointed foot" is not unusually due to atrophic contraction of the muscles of the calf.

Prevention, it need hardly be said, is in these cases far better, and certainly far easier, than cure. Often, indeed, the latter proves to be impossible. The measures to be adopted are very simple, and their efficiency depends much upon the regularity and perseverance with which they are applied. Frictions, with or without medicated liniments, bathing, shampooing, or massage, and sometimes faradization, may occasionally restore the tone of muscles which seemed at first hopelessly damaged. But no discreet surgeon will venture in a case of this kind to hold out hopes which may utterly fail to be realized.

NECROSIS, after simple fracture, is extremely rare, if it ever occur at all. Possibly in some of the cases in which blows or other injuries are followed by the death of a portion of the bone, there has really been a separation of the part thus mortified; but I have never seen an instance in which this could be proved.

After compound fractures, however, it is very common to find one or more splinters loosened and dead; their presence may interfere with the process of union, which is apt to take place promptly upon their removal.

DEVELOPMENT OF MORBID GROWTHS.—Among the remoter local consequences of fracture may be mentioned the development of tumors at the seat of the old injury. Virchow,³ after stating that enchondroma, more frequently than any other tumor, is clearly to be ascribed to traumatic causes, says:—

"Among these, fractures seem to be of great interest. Nélaton (*Gaz. des Hôp.*, 1855) mentions a man who, having broken his leg, was completely cured in two months; but six months afterward had severe attacks of pain in the part. Re-fracture occurred from slight violence, and union again took place in two months, but the part remained painful. A tumor began to develop itself, increased more and more, and at length

¹ Boston Med. and Surg. Journal, July, 1838, and Oct. 10, 1872.

² Op. cit., vol. i. p. 929

³ Die krankhaften Geschwülste, Band i. S. 482.

burst. The patient died exhausted five years from the date of the first fracture; the autopsy disclosed an enchondroma. Otto (*Seltene Beobachtungen zur Anatomie, etc.*) speaks of a woman who, two years before her death, sustained a fracture of the humerus, which united, but remained painful and became greatly misshapen; there was developed a tumor (clearly an osteoid chondroma) which acquired a colossal size. Ducluzeau (*Lebert, Traité d'Anat. Pathol.*) removed from the rib of a man an enchondroma, which had taken its origin from a fracture of the bone several years previously. Langenbeck (*Deutsche Klinik, 1860*) disarticulated the shoulder of a man aged 23, on account of a tumor which I recognized as an osteoid chondroma, and which began a year and a half after a fracture caused by a fall."

Adams¹ has recorded the history of a man who twenty-five years before his death broke his humerus; nineteen years afterward he strained it, and it remained weak; four years after this a swelling was perceived, which grew rapidly, so that amputation was thought of, but declined. The tumor ulcerated and discharged a glairy fluid; at the time of death its circumference was equal to that of the body. It was composed of enchondromatous, colloid, and compound cystic elements.

It is perhaps scarcely proper to include among the cases now under consideration those in which, fracture occurring in a person already affected with malignant tumor, the constitutional disease manifests itself afresh at the point of local injury. Here the fracture merely serves as a nucleus, as it were, around which deposit takes place, precisely as may be observed in other cases of hurts. Sometimes, indeed, it may be questioned whether the bone may not give way because its texture is already impaired by the development of disease; as in one instance recorded by Morton,² in which the woman having already a mammary tumor, the left humerus gave way as she turned in bed, and "shortly afterwards the tumor was noticed at the seat of fracture;" death occurred within three months.

The symptoms and diagnosis in these cases need hardly be discussed, and the prognosis is unfortunately but too clear. As to treatment, it must be based upon general principles; often there is no chance for anything but palliative measures. Amputation may sometimes save suffering, and delay the fatal issue.³

GENERAL PROGNOSIS OF FRACTURES.

Various circumstances must be taken into the account in forming a prognosis in any case of fracture. Among these are: the character and amount of the injury to the bone, its simple or compound character, its extent, the presence or absence of comminution, the nearness of the lesion to a joint, the amount of damage done to the soft parts. The age and previous history of the patient are also to be regarded. From a consideration of all these points, some idea may be formed as to the chances of saving the patient's life, as well as of preserving a useful and sightly limb.

With regard to the influence of the local conditions of the injury on the prognosis of fractures, it scarcely needs to be enlarged upon here, as it has been already set forth in the discussion of the phenomena and varieties of those injuries. As to age, it may be said that the fractures of children generally unite with great readiness, and that the ultimate result is apt to be the complete restoration of the shape and functions of the limb, although an ex-

¹ Trans. of Pathol. Society of London, vol. i. p. 344.

² Supplement to Catalogue of Penna. Hosp. Museum, p. 19.

³ The reader may consult with advantage: Tausch, *Zur Casuistik der vom Callus geheilten Frakturen sich entwickelnden Geschwülste*. Halle, 1881.

ception must be made in the case of epiphyseal disjunctions and fractures near the elbow-joint. In adults, the chance of permanent deformity and of stiffening of the joints is greater, and in old persons it is very apt to occur. Some of the fractures to which old people are liable, and especially those of the cervix femoris, are almost sure to end in non-union and lameness, if not total disability, for the remainder of life.

Of fractures of certain bones—the patella, and the olecranon and coronoid processes of the ulna—the result is, as a rule, union by fibrous tissue only, and the necessity of advising the patient of this fact beforehand must be quite obvious. In all cases the surgeon should insist most positively upon obedience to his directions, and should remember that if he is lax in this respect, any damage resulting from the waywardness of the patient will be laid at his door.

It is better always to give a guarded prognosis even in simple cases, as may be inferred from what has been said in previous pages as to the occasional occurrence of unexpectedly serious symptoms. And even in the matter of time, a prudent surgeon will be slow to make promises which he may not be able to fulfil. For example, if a man with a broken leg is assured that he will be able to walk in six weeks, he will be very much dissatisfied if a cure is not effected in less than two months. And if a man with a fractured femur is told that he will be able to walk as well as ever, he will naturally be disappointed if he finds himself with a shortening which involves a permanent limp in his gait.

REPAIR OF FRACTURES.

Although the process of repair of broken bones has been the subject of study and discussion by many of the ablest surgical observers and writers, it is not as yet thoroughly understood, many points remaining unsettled. I shall try to give such a practical summary of what is known in regard to it as may accord with the limits of the present article, referring the reader who desires further information to the admirable description given by Paget,¹ and to the more recent works of Cornil and Ranvier,² and of Billroth.³ In Todd and Bowman's *Cyclopædia of Anatomy and Physiology*,⁴ there is an excellent exposition of the opinions advanced up to the date of its publication (1836), by Dr. W. H. Porter; and Virchow⁵ has presented a very interesting account of the result of his own researches.

This subject may be studied in various ways. By careful observation of clinical cases, the general phenomena are learned, and further explained by the opportunities afforded of dissecting the parts in patients dying at different periods after the receipt of these injuries. Experimental fractures produced on animals may be examined with advantage, allowance being made for known differences between them and human beings. Microscopical investigations have thrown much light upon the modes of development of the reparative material.

When a bone is broken, some injury is always inflicted on the *periosteum*. Its fibres may be merely stretched, but more frequently they are torn across at

¹ Lectures on Surgical Pathology, Lecture XI.

² A Manual of Pathological Histology. By V. Cornil and L. Ranvier. Translated from the French by Drs. Shakespeare and Simes. Philadelphia, 1880.

³ General Surgical Pathology and Therapeutics. By Theodor Billroth. Translated from the German by Dr. Charles E. Hackley. New York, 1871.

⁴ Art. "Bone, Pathological Conditions of." *Op. cit.*, vol. i.

⁵ Cellular Pathology. Chance's translation, 1860.

the convexity of the angle formed by the fragments. At the same time, on the other side, where they are not ruptured, they are apt to be stripped up for a greater or less distance along the bone. Occasionally, when the fragments are violently forced apart, the periosteum may be completely severed; but even then, before it yields, it is probably loosened from the surface of the bone. Towards the broadened ends of the long bones, and in the thick and flat bones, this stripping up is less, and the complete severance of the periosteum is not apt to occur.

By the violence causing the fracture, the surrounding *soft parts*, as well as the *marrow*, are also lacerated, and an effusion of blood takes place at the seat of injury. This blood is derived chiefly, of course, from the more vascular of the tissues, and varies in amount in different cases. Immediately succeeding the infliction of the injury there is set up an inflammatory condition, which gradually subsides, and then the work of repair begins, perhaps in the majority of cases early in the second week.

This process of repair does not differ in any essential respect from that of wounds of the soft parts, except that the final result is the production of new bone, and hence that the lymph or plasma must undergo ossification, instead of conversion into ordinary cicatricial tissue.

Of the blood which was poured out from the vessels of the bone itself, of the marrow, and of the surrounding soft tissues, a portion, and perhaps a large part, is undoubtedly absorbed. But a part of it very probably remains and becomes organized, contributing to form the uniting medium.

This uniting medium, constituted by lymph or plasma derived from the tissues around the broken bone, from the bone itself, from the periosteum, and from the marrow, is called, as it begins to assume firmness, *callus*. Whatever may be the abundance of the material formed around the fracture, it becomes permanent only between the fragments; although there are some cases, to be hereafter mentioned, in which masses of this callus, deposited all about the seat of fracture in an aimless and capricious manner, become ossified, and are never gotten rid of. There may be a large production of lymph about both fragments; but the superfluous portion is as a general rule wholly absorbed, and the form of the bone as nearly as possible restored.

According to Paget, there may be an *immediate union* of a broken bone, as in the healing of wounds of the soft parts by "primary adhesion," without any uniting medium; the continuity of vessels and other textures being simply renewed. But this must be extremely rare, and I know of no cases on record in proof of its occurrence. In some instances, which would seem to be specially likely to present this immediate union, it certainly does not occur; as, for example, in fractures of the clavicle without displacement, the periosteum seeming to remain intact. Here there is always, after a few days, a very marked swelling, which hardens and is gradually absorbed, just as callus does in the majority of cases.

By some of the older authors it was laid down as a rule that the callus was deposited around the fragments, so as to form a wide, flat "ring" about them—a sort of splint—and within them, so as to make what was called the "pin." To the former was given also the name "provisional callus," as it was supposed to be merely temporary.

Paget, whose views have met with general acceptance, says:—

"The normal mode of repair in the fractures of the human bones is that which is accomplished by 'intermediate callus.' The principal features of difference between it and that just described are: (1) that the reparative material or callus is placed chiefly or only between the fragments, not around them; (2) that, when ossified, it is not a provisional, but a permanent, bond of union for them; (3) that the part of it which is

external to the wall of the bone is not exclusively, or even as if with preference, placed between the bone and the periosteum, but rather in the tissue of the periosteum, or indifferently either in it, beneath it, or external to it."

He, however, admits that in the ribs, and occasionally in the clavicle and humerus, an ensheathing callus may occur, in consequence of unrestrained movement of the fragments, just as it does, as a rule, in animals. Yet, even in the latter, the ultimate result may be a much more complete restoration of the normal form of the bone than would be expected. Mr. Crisp exhibited to the Pathological Society of London¹ a specimen of oblique fracture of the humerus of a gorilla, united without deformity; and stated that this was only one out of many, in animals and birds, in which union was as perfect and the limb as useful as if splints had been applied.

We occasionally meet with cases, as has been already said, of voluminous formation of callus, much beyond the needs of the mere reparative process. Such a deposit, about a fracture of the shaft of the femur, is represented in the annexed diagram (Fig. 806). But in by far the largest number of cases, upon the subsidence of the inflammatory swelling immediately following the fracture, there is left merely enough new material to bridge over the interval between the fragments (for if they are not in exact apposition there will be a triangular or wedge-shaped gap of greater or less size on either side), and thus restore as nearly as may be the normal shape of the bone.

When the fragments are wholly separated and driven apart, and the periosteum torn entirely asunder—an occurrence which is very rare, even when the ends of the fragments overlap one another in a marked degree—each fragment may, like the end of the bone in a stump after amputation, become closed in by a rounded shell of compact bone. Such is the case in some instances of ununited fracture, as will be presently more particularly described. But often when the fragments are separated, there is still a bond between them in the shape of the bridge of periosteum before spoken of; and in the space defined by this bridge there will be developed a mass of callus which, becoming ossified, connects the two fragments permanently, and may even acquire the cancellous structure proper to the medullary cavity, as well as the compact wall, of the shaft of the normal bone.

I believe it may be stated, without any exception whatever, that the periosteum is thickened and swollen in the neighborhood of a fracture. By some writers, and especially by Ollier,² this membrane has been described as endowed with the power of promoting the formation of bone in adjacent plasma, and even in the soft tissues if transplanted among them. That it has such a power, exercised in the original development of the skeleton, cannot be doubted; and from the statements just made as to the usual condition of the periosteum in cases of fracture, and as to the relation of the callus to the broken ends, the inference is

Fig. 806.



Voluminous callus in fractured femur.

¹ Transactions, vol. xxvii. 1876, p. 340.

² *Traité Expérimentale et Clinique de la Régénération des Os, etc.* Paris, 1867.

clear that the uniting material is formed under the osteogenetic influence of the periosteal membrane.

Marcy¹ quotes the statement of Ercolani that neither the periosteum nor the ends of the fractured bone are concerned in the formation of osseous callus, but that the periosteum is destroyed at the points where callus is formed. He thinks that the material for the callus is furnished from the blood of the lacerated vessels of the injured tissues, including those of the medulla and Haversian canals. In healed fractures, both in man and animals, he found definite evidence of atrophy of the ends of the fragments. And from his experiments on animals, he concludes: that the old periosteum at the point of injury becomes destroyed; and that the exudation from the parts surrounding the fracture is well developed as early as the sixth or eighth day, and covered with a new periosteum. By the osteogenetic action of this new membrane he thinks that the exuded cellular elements are transformed into bone. Hence Klein² observes:—

“From the description of the appearances in the microscopical specimens as given in the paper, it appears that the formation of the osseous callus takes place in essentially the same manner as that described by Billroth, that is to say, the new bloodvessels and the cells of the soft callus, as well as the new periosteum—or rather its osteogenetic layer—it seems, are derived from the medullary tissue of the Haversian canals at the extremities of the fractured bone.”

As to the mode in which the uniting material, the blastema, whencesoever derived, becomes bone, authorities have differed. Paget says:—

“It may become, before ossifying, either fibrous or cartilaginous, or may assume a structure intermediate between these; and in either of these cases, ossification may ensue when the previous tissue is yet in a rudimental state, or may be delayed till the complete fibrous or cartilaginous structure is first achieved. . . .

“The new bone, through whatever mode it is formed, appears to acquire quickly its proper microscopic characters.” Its corpuscles or lacunæ, being first of simple round or oval shape, and then becoming jagged at their edges, subsequently acquire their canals, which appear to be gradually hollowed out in the preformed bone, as minute channels communicating with one or more of the lacunæ. The laminated canals for bloodvessels are later formed. At first, all the new bone forms a minutely cancellous structure, which is light, spongy, soft, and succulent, with a reddish juice rather than marrow, and is altogether like fetal bones in their first construction. But this gradually assimilates itself to the structure of the bones that it repairs; its outer portions assuming a compact laminated structure, and its inner or central portions acquiring wider cancellous spaces, and a more perfect medulla. It acquires, also, a defined periosteum, at first firm, thin, and distinctly lamellar, and gradually assuming toughness and compactness. But in regard to many of these later changes in the bonds of union of fractures, there are so many varieties in adaptation to the peculiarities of the cases, that no general account of them can be rendered.”

Virchow's description of the formation of callus may also be quoted, as it gives in some respects a fuller idea of the process, and from a slightly different stand-point. He says:—

“The pre-existence of cartilage is by no means necessary for the formation of bone; on the contrary, an osteoid substance is very frequently formed by a direct sclerosis in connective tissue, nay, ossification is thus really more easily effected than when it takes place in real cartilage. We see also by the history of the theories concerning callus, that the endeavor to show that it is always developed in the same way or out of the same substance (*e. g.*, extravasated blood, periosteum, medullary tissue, exuded fluids, etc.), has proved the greatest obstacle to the true perception of the real state of things,

¹ Trans. of Amer. Med. Association, 1881, pp. 907 *et seq.*

² London Medical Record, Feb. 15, 1882.

and that all have really had right upon their side, inasmuch as new bone in fact builds itself up out of the most different materials. Unquestionably, when the case runs a very favorable course, that path is chosen in which the new formation can be most conveniently effected, and it is by far the most convenient way when the periosteum produces a very large portion of the whole. This takes place in the following manner: the periosteum grows dense toward the edges of the fracture, and there gradually swells up, the swelling being of such a nature that separate layers or strata can afterward be pretty clearly distinguished in it. These continually become thicker and more numerous, in consequence of the constant proliferation of the innermost parts of the periosteum, and of the formation, by means of a multiplication of their cellular elements, of new layers, which accumulate between the bone and the relatively still normal parts of the periosteum. These layers may become cartilage, but it is not necessary, nor yet the rule. For we find that, in the greater number of favorable cases of fracture, where cartilage is produced, not the whole mass of the periosteal callus is produced from cartilage, but a greater or less portion of it is always formed out of connective tissue. The layers of cartilage generally lie next to the bone, whilst the further we proceed outward, the less does the formation out of cartilage, and the more a direct transformation of connective tissue, prevail.

"The formation of bone is, however, by no means restricted to the limits of the periosteum—very commonly it extends beyond them in an outward direction, and often penetrates, in the form of spicula, nodules, and protuberances, to a very considerable depth into the neighboring soft parts. It is self-evident that in these cases we have by no means to deal with any proliferation of the periosteum in an outward direction, but that an ossifiable tissue arises out of the interstitial connective tissue of the neighboring parts. Of this it is very easy to convince one's self, because osseous spicula are found shooting up in the interstitial tissues of the neighboring muscles. In the preparation from the fractured ribs [previously shown], places are still to be found in the external parts, where fat has been included in the ossification. It cannot be said, therefore, that the formation of callus around fractured parts is altogether a periosteal formation."

Virchow then goes on to speak of a different mode of development of callus, "that, namely, which takes place in the midst of the bone *from the medullary tissue.*"

"At the moment when the bone in a case of fracture is shivered, a number of little medullary spaces are naturally opened. In the neighborhood of these, the still closed medullary spaces are seen nearly invariably, when matters take a regular course, to become filled with callus, new lamellæ of bone attaching themselves to the internal surface of the osseous trabeculæ which bound the spaces, just as in the ordinary growth of bone in thickness, the originally pumice-stone-like layers become compact by the deposition of concentric lamellæ. In this manner it happens, that after some time a larger or smaller new layer of bone is found, filling up the end of the medullary canal of each fragment so as to occasion its occlusion. This is a kind of new formation which has nothing in common with the former one, as far as their starting-points are concerned, but has its origin in quite another tissue, and is altogether different in its palpable result, inasmuch as it produces, within the confines of the old bone, a condensation of that portion of the marrow which lies in the immediate vicinity of the fracture. Even in cases where the ends of the bones perfectly coincide, an internal formation of bone such as I have described takes place in the medullary canal of each fragment, producing its occlusion.

"These two kinds are the usual and normal ones. Around the two fractured ends, the swelling takes place; in the interior, the condensation. Gradually—in proportion as the extravasated blood is absorbed—the new masses of tissue which have been developed between the broken ends draw nearer to one another, and round about the fracture there forms a bridge- or capsule-like communication by means of the ossification of the soft parts. There is, therefore, but little reason to ask whether the callus proceeds from free exuded or extravasated matter. No doubt an extravasation takes place in the first instance into the space between the fractured ends, but the extravasated blood is generally pretty completely reabsorbed, and it contributes comparatively but very little to the real formation of the subsequent uniting media."

Ranvier thinks that the new bone constituting callus is always, in simple fractures, developed through a cartilaginous stage, but this is at variance with the views of other observers.

Mr. J. Greig Smith has published¹ an interesting article on the histology of fracture repair in man, giving the results of the examination of a number of specimens at various stages of the process. He sums them up as follows:—

“A plastic, parent tissue is provided partly by the swollen and inflamed pre-existing tissues, partly by organized inflammatory neoplasm. The ossific stimulus lays hold of this parent tissue and infects it with the first change toward ossification, viz., calcification. The calcifying process proceeds along numerous irregularly disposed lines through the parent tissue, modifying it before it finally completely invades it. This modification of matrix ahead of the line of calcification consists chiefly of a swelling of the intercellular substance, bringing about an occasional resemblance to ordinary hyaline cartilage. When the process is completed by the formation of an areolar calcified tissue containing variously modified embryonic substance in its meshes, we have the great mass of so-called bony callus. This callus material soon begins to undergo the further changes toward true ossification; namely, absorption of the calcified substance and development on these calcified lines of true lamellar bone by osteoblasts derived from out-growing marrow or cambium layer of periosteum.”

As to the individual tissues concerned, he thus summarizes:—

“*Blood-clot.*—The greater part of the effused blood is absorbed and disappears. Some amount of blood-clot usually remains in certain positions to become organized. After organization, more or less perfect, it may either directly become a parent tissue for bony growth, or undergo a further transformation toward this end. Blood-clot organizes by preference in the exposed medullary canal and over the jagged ends of the broken bones. Where it forms the chief nidus for ossification, bony union is longest delayed.

“*Periosteum.*—Periosteum contributes to fracture repair rather by virtue of its position as a fibrous tissue than through its ordinary function as a bone-producer. Periosteal callus is rather a calcifying cellulitis than an ossifying periostitis. Periosteum does not undergo very much change preparatory to calcification. The calcified periosteal trabeculae are the least perfectly developed and the most unstable of all the areolar bony callus material. Shreds of periosteal fibre traversing embryonic inflammatory tissue contribute materially to the rapidity with which calcification is carried out.

“*Tendon and Ligament.*—Where present, these tissues play an important part in the ossifying process. Sometimes undergoing calcification without exhibiting material change of structure, they frequently, however, are subjected to preparatory modifications which assimilate them in appearance to true cartilage, and thereafter behave in ossification as ordinary cartilage does. The presence of an abundance of ligamentous tissue should warn us of a possible overgrowth of uniting bone.

“*Fibro-cartilage.*—White fibro-cartilage may become calcified without undergoing preliminary structural changes. The calcareous deposit is finely divided and dense; and the advent of the absorptive process is long delayed. As a temporary bond of union, it is, when once formed, the strongest of all.

“New inflammatory tissue contributes to bony growth after it has been in varying degrees assimilated to the formed tissues in its neighborhood. Occasionally it assumes a resemblance in structure to hyaline cartilage.”

After the callus has been deposited and ossified, and the bone has begun to acquire strength, there still remains the modelling process to be accomplished; in other words, projecting points, edges, or other roughnesses have to be removed by absorption, so as to restore as nearly as may be the normal form of the bone. This is brought about in the same way as in the case of a bone sawed through squarely in an amputation, which becomes in time rounded off by a shell of compact bone, usually thin, and backed up by lamellae nearly

¹ Journ. of Anatomy and Physiology, Jan. 1882.

as regular as those already described as seen in sections through the articular extremities. Sometimes the new wall is thick and almost ivory-like in density and hardness; but it is always present, so that the medullary cavity is invariably covered in. Probably there is in the first place a formation of new bone, which scarcely acquires its density and hardness before the absorption of the outer and irregular portions of the old bone begins. How long the modelling process lasts, cannot well be determined; but it is most likely that it always occupies more time than all the rest of the repair of the injury. Sometimes it is not completed for many months after the bone has in great measure resumed its function.

Thus far reference has been made to the reparative process in cases of fracture of the shafts of the long bones. When the breakage extends into a joint, so as to involve the articular cartilage, we find that although the joint-cavity may have been seriously damaged, perhaps filled with blood, the ultimate result may be very good. The blood becomes absorbed, the secretion of synovia is restored, and the end of the bone may show no trace of the solution of its continuity beyond either a groove or a depression. For, perhaps owing to the absence of periosteum, callus is not thrown out at the portion of the fracture corresponding to the joint; and if the fragments can be kept in accurate apposition, there will be no such bulging of new material as exists around the fragments elsewhere.

The same may be said of fractures of the patella. Here, if the broken portions can be kept in contact, so as to become united by bone, this will be found on the anterior surface to be marked by a more or less distinct ridge, while posteriorly, or on the joint surface, there will be rather a depression, as if there had been material absorbed instead of deposited.

Like all the other processes of nature, and especially like all the other processes of repair, the healing of broken bones takes place in obedience to certain general laws; and although in the majority of cases the result thus provided for is good—is, indeed, the best attainable as far as nature is concerned—still instances occur in which these blind forces work harm. Thus, in the case of fractures near the joints, the deposit of new bone may be such as to hamper the movements of the limb most seriously. In fractures of the forearm, the callus of one bone may unite with that from the other, and the resulting osseous bridge may do away altogether with the possibility of the pronation and supination of the hand, rendering it almost, if not wholly, useless. Nature is wholly indifferent to the individual; and it is for the surgeon to watch and guide her reparative efforts in each instance.

Fractures of *cartilage* are sometimes met with, and are repaired by means of a copious deposit of material analogous to the callus of bone. In the "Wistar and Horner Museum" of the University of Pennsylvania, there is a specimen of fractures of the sixth, seventh, and eighth costal cartilages of the right side, each surrounded by a somewhat irregular bony ring. A very similar specimen is in the Mütter Museum of the Philadelphia College of Physicians. Paget thinks that this occurs only in the costal and laryngeal cartilages, which have a tendency to ossify in advanced life.

When an articular cartilage is involved in a fracture of the bone to which it belongs, it does not seem ever to be fully repaired; a groove lined by fibrous tissue always marks the line of injury.

The repair of *compound* differs from that of *simple* fractures, in the fact that suppuration is almost inevitable, and that granulations spring up about the injured and exposed bone, by the ossification of which union takes place. In point of actual damage to the bone, many compound fractures are less

serious than many simple fractures. And as soon as, by the process of granulation or by adhesion, the soft parts have closed in over the bone, repair goes on as rapidly as if the fracture had been simple throughout. No law can be laid down as to a definite difference between simple and compound fractures, in the length of time required for their repair.

According to Cornil and Ranvier,¹ in compound fractures—

“The changes occurring are identically the same as in osteitis; at all the irritated points of the surface of the solution of continuity, the marrow becomes embryonic, and undergoes changes similar to those of a simple osteitis. Under the periosteum, the new embryonic marrow soon forms osseous trabeculae; five or six days after the accident they may be found. The Haversian canals opened by the fracture are enlarged through the absorption of the osseous substance limiting them; the vessels and marrow which they contain contribute to the formation of the granulation tissue. The marrow in the central medullary cavity undergoes the same modifications, although more slowly. Thus, over the whole surface of the solution of continuity, there are formed granulations which enlarge and by uniting together constitute an embryonic or inflammatory tissue, in the midst of which osseous trabeculae are developed, as in the physiological method of ossification. The needle-like points of the old bone seem always to act as a base for the new osseous formation. Growing in every direction, uniting one with the other and with the opposite fragments, they limit the spaces filled with the embryonic marrow. These spaces are gradually narrowed by the addition of new osseous layers, and consolidation is brought about by a firm adhesion between the two fragments of bone.”

It is very necessary to remark, that, while this distinction between the mode of union in simple and compound fractures is clearly to be discerned, the two processes are often combined in the same case. Thus, either from the very first or from a later period, the deeper portions of a broken bone may be entirely excluded from the air; and hence in these the repair goes on by the method described for simple fractures, by the ossification of lymph or plasma passing through a stage of more or less complete development of fibrous or cartilaginous structure. At the same time, granulations are forming about the exposed portions of the injured bone, and here the uniting medium, the callus, will be the direct result of the ossification of those granulations. Cicatricial tissue will be developed for the repair of all the damage to which the air finds access, and will take on the structure of the parts united. At first the scar in the skin will be closely adherent to the new-formed reparative bone; indeed, it sometimes remains so permanently. But in many cases there is a gradual stretching of the intermediate layer, until a very good imitation of normal areolar tissue allows the cutaneous cicatrix to play freely over the bone even where the fracture existed. This, however, corresponds in time to the later stages of the modelling process.

DEFECTS IN THE PROCESS OF REPAIR OF FRACTURES.

In the vast majority of cases of fracture of the long bones, osseous union takes place in due course. As the surgeon from time to time, during the period of treatment, handles the limb, he finds the fragments less and less movable upon one another, until at last they do not yield at all, and the patient himself becomes able to exert some muscular power upon the restored bone. Clinical observation has determined pretty nearly the average period at which, under ordinary circumstances, consolidation may be looked for in the several portions of the skeleton; and in general we do so expect it. But cases are met

¹ Op. cit., p. 210.

with in which the fragments remain movable; and the conditions of this failure to unite are now to be considered.

These cases have been divided into those of delayed union, of dissolved union, of fibrous union, of complete separation of the fragments, and of pseudarthrosis or false-joint properly so called.

DELAYED UNION is by no means uncommon. Scarcely a year passes that I do not see one or more instances in my hospital wards, and I have repeatedly been consulted about such cases in the private practice of others. It is not always easy to assign a *cause* for the failure, which may occur under the best treatment, and in persons seemingly of good general health. Porter¹ speaks of having "seen two cases of fractured femur remain ununited at the end of five and six months, in the persons of fine and healthy young men, although the ends of the bones were kept in apposition, and in every other respect the treatment was correct." I have myself seen union delayed oftener in the leg than elsewhere, and in some of the instances the fracture has been extremely oblique; the patients have been for the most part male adults of the laboring class, of middle age; although one, in private practice, was a very young man in excellent circumstances, and rather remarkably robust.

Although more frequent in men, delayed union is met with in women also, and among its constitutional causes *pregnancy* has been assigned by some writers a prominent place; but against the cases adduced in proof of this view must be set a great many in which the cure has been rapid. One such occurred to me at the Episcopal Hospital, in 1871.² In like manner, the evidence is conflicting as to the influence of *syphilis*, of *cancer* (not affecting the bone itself), of *paralysis*, of *old age*, and of great *losses of blood*; as to all these, while there are instances on record of their apparent influence in retarding the union of fractures, there are enough in which they seemed to have no such effect, to make the matter at least doubtful. The reader will find these various cases detailed in the systematic works of Malgaigne, Gurlt, and others. Norris³ has discussed the subject at great length and very instructively.

The influence of very long-continued *low diet*, and of the debility thus induced, in hindering the consolidation of fractures, is much more clearly proved. In two instances, one recorded by Thierry⁴ and the other by Poncet,⁵ the repair of fractures seemed to have been delayed by indulgence in *sexual intercourse*, and took place promptly on the withdrawal of the opportunity for such indulgence.

Among *local causes* of delayed union there are some which seem to be unquestionable. *Wide separation of the fractured ends*, by a bad position of the fragments, or by loss of substance, may have this effect. Here there is more to be done, and nature takes longer to do it. The wonder is that union is not in some of these cases totally prevented. Norris⁶ says: "In the case of a boy aged 12, who came under my care in the Pennsylvania Hospital in 1837, two inches of the tibia was removed, notwithstanding which he was discharged cured in eleven weeks, with shortening of the limb of but half an inch, the space occupied by the removed bone being filled by a firm and even callus." When the fragments are widely separated, it is very hard to prevent some disturbance of their relative position; and this may be sufficient to pull upon the as yet fibrous uniting medium, and interfere with its ossification, though not enough to induce actual inflammation. In like manner, an *attempt*

¹ Cyclopædia of Anatomy and Physiology, vol. i. p. 447.

² Philadelphia Medical Times, Feb. 1, 1872.

³ Contributions to Practical Surgery, pp. 23 *et seq.* Philadelphia, 1873.

⁴ L'Expérience, 4 Nov. 1841.

⁵ Brit. Med. Journal, March 18, 1882.

⁶ Op. cit., p. 42.

to use a broken limb before the callus has become firm, may so disturb the newly developed tissue as to postpone its ossification for a time.

At the present day scarcely any surgeon can be found who would make use of *wet dressings* to a fractured limb after the inflammatory stage; and hence the prolonged employment of such applications, as a cause of delayed union, need be only mentioned as a matter of history.

Tight bandaging, it is to be feared, is sometimes practised, especially by surgeons in the country, who cannot frequently visit their patients; yet it is all the more dangerous under such circumstances. That it may induce gangrene of the limb is well known; but when not sufficient for this, it may very probably so far interfere with the nutrition and innervation of the part as to delay the process of repair.

Occasionally the interposition *between the fragments* of a portion of muscle, of a separated splinter, or of a foreign body, may cause a long delay in union, or, unless either removed or absorbed, may wholly prevent it. A curious case is quoted by Norris,¹ "in which the fragments of a clavicle, separated to the extent of an inch by the subclavius muscle, were united together very solidly by two bridges of newly-formed bone, in the centre of which the muscle, *itself ossified*, was imprisoned."

Necrosis or other disease of one or both fragments may hinder consolidation, until by appropriate measures the disease has been set aside or the necrosed portions removed.

The *ligation of the main artery* of the limb, sometimes rendered necessary by a wound, has occasionally been thought to interfere with the union of a fracture by cutting off the vascular supply. But, in other instances, as in a case recorded by Mr. Bransby Cooper², the process of repair seems to take place quite as readily as under other circumstances.

As to the effect of *nerve injuries* upon the repair of fractures, there is a decided conflict of evidence. Thus Travers³ gives the following case:—

A man had his fourth and fifth lumbar vertebræ fractured and dislocated by the falling of a load of gravel upon his loins as he was working in a pit. At the same time the bones of his right leg and his left upper arm were fractured. These were adjusted and set; the lower limbs, bladder, and rectum were paralyzed immediately, but the loss of sensation was gradual, and both sensation and motion were partially restored before his death. He lived eight weeks, notwithstanding two attacks of peritonitis. At the end of five weeks the fractured arm was perfectly united; the bones of the leg were unchanged, and exhibited not the slightest advance toward union; but at the time of his death some thickening of the fractured ends had taken place, and the process of union seemed to be at length commencing.

On the other hand, Kusmin⁴ found that, in animals experimented on by him, the callus was larger and harder on the side on which the nerves had been divided. This was still the case after four or five months. The process of ossification was more rapid, and the result was true bone. The bony formation in the cartilaginous callus occurred in the earlier stages as a metaplastic process. The first signs of ossification began in the coaptated fragments in the neighborhood of the outer periphery of the old bone, and under the periosteum, markedly earlier and to a greater extent when the nerves had been divided.

The amount of mobility at the seat of fracture, when the consolidation is hindered by any of the circumstances now mentioned, varies somewhat; but

¹ Op. cit., p. 48.

² Lancet, Dec. 5, 1840.

³ Further Inquiry, etc., p. 436.

⁴ Ueber den Einfluss der Nerven-durchschneidung auf die Callus-bildung bei Fracturen. Allg. Wiener Med. Zeitung, Nos. 33, 34, und 35, 1882.

it is apt to be only slight, and its development by the surgeon's hands is attended with pain, which may be quite severe. The bone remains useless as a lever or as a means of support. A certain degree of œdema of the limb is often present; the skin is apt to be harsh, and the muscles of the part are flabby.

It is probable that the callus is in all these cases formed as far as the fibrous or fibro-cartilaginous stage, and that the delay is simply in its ossification; but I know of no instance on record in which an opportunity has been afforded of determining the state of the parts by dissection.

Under appropriate treatment, to be hereafter detailed, the full development of the uniting medium is generally brought about, and a good result at length obtained.

DISSOLVED UNION is much more rare than the foregoing condition. Under this head are embraced cases in which, callus having formed, and the fragments having become solidly united, the reparative material softens again and disappears, and the mobility recurs. While there are not many such instances on record, there are enough to establish the possibility of the phenomenon.

The most frequent *cause* of this breaking down of formed callus is the occurrence of some systemic disorder. Thus, in Chaplain Walter's account of Lord Anson's voyages,¹ the case of a sailor is mentioned who was attacked with *scurvy*, and "the callus of a broken bone, which had been completely formed for a long time, was found to be hereby dissolved, and the fracture seemed as if it had never been consolidated."

Norris,² speaking of the influence of *erysipelas*, says that he has "seen a rapid absorption of a large callus, which had produced firm union of a fracture of the lower third of the leg, occur, without any apparent cause, to such an extent as to render the fragments very movable, and necessitate a renewal of the treatment."

Fevers have been known to have a like effect, as in a case reported by Schilling.³ An artilleryman had a fracture of the left femur, September 1, which, by the middle of November, was so firmly united that he could bear some weight on the foot. He was then attacked with typhus abdominalis (typhoid fever), and ten days afterward callus could no longer be felt, the bones moving as freely upon one another as just after the injury. In six days more the patient died. The examination exhibited no trace of callus; the broken surfaces were bloody, like those in a recent fracture, and were surrounded by a sac-like membrane, which contained some bloody fluid. Similar cases have been recorded by Mantell⁴ and others.⁵ A very curious case is reported by Clarke,⁶ of a fast-growing boy, who had a fracture of the arm, which united; he returned to school, overworked himself in trying to obtain a prize, and broke down in health, when the fragments were found to have become disjoined.

Occasionally the retrogression does not stop here, but the fragments themselves become absorbed, as in the very remarkable case recorded by Jackson and Dwight,⁷ in which almost the entire humerus disappeared after the occurrence of a second fracture. A case in many respects analogous to this is

¹ A Voyage Round the World, etc., vol. i. p. 120.

² Op. cit. p. 52.

³ Med. Zeitung, Sept. 16, 1840; Am. Journal of the Med. Sciences, April, 1841.

⁴ Lancet, Oct. 9, 1841.

⁵ Morgagni, De Sedibus et Causis Morborum, Alexander's translation, vol. iii. p. 308; Gage, Trans. of New Hampshire Med. Society, 1875, p. 93; Hammick, op. cit., p. 176.

⁶ Med. Times and Gazette, Nov. 16, 1867.

⁷ Boston Med. and Surg. Journal, July, 1838, and Oct. 10, 1872.

described by Gross.¹ In neither of these instances was there any apparent cause for the destruction of the bone.

As far as can be judged from the observations published, the removal of the constitutional disorder, when it can be effected, is followed by a renewal of the process of repair of the fracture, which ultimately becomes thoroughly united.

FIBROUS UNION OF FRACTURED BONES.—The cases of *fibrous union* differ from those already described, in that the fragments become closed in at their ends by a rounded shell of bone, sometimes very thin, but more generally thick, hard, and dense; while between them and connecting them there exist fibrous bands resembling interosseous ligaments. These bands may attach the fragments end to end, in which case there has probably been absorption of some portion of bone, perhaps separated as a splinter at the time of injury; or, when there is overlapping of the fragments, the fibrous bands may bridge over the interspace between them. It seems highly probable that in some cases these bands may be in reality remnants of interosseous membrane or of intermuscular septa.

Sometimes a condition of this kind is not easy to distinguish clinically from that of false-joint, properly so called, to be presently described. But there is generally, from the length of the bands and the comparative freedom of the fragments, an even greater degree of mobility; the limb hangs like a flail, and is useless except for such actions as involve merely a straight pull on the part of the muscles.

Most of the systematic writers are at pains to assure us that results such as these have never ensued in cases treated by them; and in the majority of the instances on record, the patients have been sailors, who met with their fractures while at sea, and who were thus unavoidably deprived of the benefits of treatment until a long while—weeks or even months—had elapsed. From this fact, as well as from the general tenor of the other evidence in regard to the matter, it seems to me as if fibrous union were due much more generally to local causes than to any constitutional disorder. This view, which was maintained by Stanley, Callender, and others, has been opposed by some respectable authorities, but I think partly because the just distinction has not been drawn between these cases and those of mere delayed union.

Fibrous union is very often the only form attainable in certain bones—the patella and the olecranon, for example; and here, if it is close enough, the functions of the limb may in time be almost completely resumed. But it may also occur in any of the long bones, especially in fractures of both bones of the forearm, and in those of the cervix femoris.

The amenability of these cases to treatment is generally in inverse ratio to the time of their existence; if seen and recognized early, they may be dealt with far more readily, and the chance of success from mild measures is much greater, than if the condition above described has become thoroughly established. In the latter state of things, there is very little hope of amendment except from operative procedures, often difficult, and by no means free from danger. Sometimes, by means of prothetic apparatus, the limb may be so far stiffened as to enable the patient to use it to a certain extent. The other plans of treatment will be presently described.

COMPLETE SEPARATION of the fragments is very rarely met with, and is probably always the result of atrophy of one or both portions. Norris² speaks of these cases; and I think that I have seen such a condition in the humerus,

¹ Op. cit., vol. i. p. 929.

² Op. cit., p. 21.

but I could not be sure that there was not a connection by very long and loose fibrous strips, between the ends of the bone. No case is known to me, in which complete separation has been placed beyond a doubt by dissection.

FALSE JOINT OR PSEUDARTHROSIS.—This term is strictly applicable only to cases in which there is formed at the seat of fracture an imitation of a normal articulation, as in the annexed diagram (Fig. 807). The periosteum, and perhaps other fibrous tissues in the neighborhood, become thickened and developed into a sort of capsule. By constant motion upon one another, the fragments become rounded, one at the centre of the end, the other at the margin, so that one is convex and the other concave; and between them, within the newly-formed capsule, there occurs a secretion not unlike the synovia of a true joint.

This state of things is more apt to occur, or, at least, has been oftener met with, in the shaft of the humerus than elsewhere; but it is not always easy to ascertain from the statements of writers what the exact condition of the bones may have been in cases treated by them. And, indeed, it may be questioned whether it would not be well to retain simply the two terms, *delayed union* and *false joint*, the latter embracing all the cases in which, whether with fibrous union loose enough to admit of a wide range of motion, or with an imitation of a joint cavity between the fragments, there is obviously a permanent condition of mobility at the seat of fracture. With this understanding, which seems to have been already assumed by many writers, the discussion would be simplified, without any real sacrifice of scientific accuracy; since, in the case of fibrous union, we have an imitation of a joint in its great essential, mobility, and, in the other case, we have but an imitation of the structures proper to a normal articulation. Clinically, the two conditions are the same (except in the treatment required, which is to be referred to again hereafter); they both differ from delayed union in the important point that the mobility in them is unattended with pain.

Otto¹ says that pseudarthrosis is not unfrequent in animals; he has seen it in dogs, cats, a fox, and several birds. He quotes Greve as having met with one example in a hare, and Tenon with one in a cat. These were probably verified by dissection.

Details of the various plans available for the treatment of the defects in the reparative process of fractures will be given in the section on the general treatment of these injuries.

UNION WITH DEFORMITY is almost invariably the result either of want of treatment, of improper or negligent treatment, or of the restlessness of the patient. It may be simply the perpetuation of the distortion impressed upon the limb from the time of the accident, or it may be a new displacement brought about by causes acting on the limb at a later period.

Permanent deformity after fracture is by no means uncommon, and in some cases is absolutely unavoidable, by reason of the difficulty of maintaining the fragments in proper position. It may be very slight, or it may be so great as to entail upon the patient the most annoying disfigurement, and often very serious disability. Like that spoken of among the symptoms or phenomena of the original injury, it may be either angular, rotary, or lateral. One of the main objects of treatment is to prevent it; to keep the fragments of the

Fig. 807.



Diagram of false joint.

¹ Op. cit., p. 140.

broken bone in their normal relation, or as nearly so as may be possible, until by natural processes the repair has been fully accomplished.

Angular deformity depends for its importance largely upon the degree of the angle and the precise seat of the injury. The most frequent and striking instance of it is in the bowing outward of the femur after fracture of its shaft. Near the lower end of the humerus, an angle forward may cause great and annoying limitation of the flexion of the elbow. These and other points will, however, be discussed at greater length in connection with the special fractures concerned.

Rotary deformity is fortunately not very common. Its disastrous effect in the lower extremity, in fractures of the thigh or leg, needs no demonstration. It is not unfrequently seen in fractures of the neck of the thigh-bone, the foot remaining permanently everted; but here the disability from other causes is apt to be so great as to make the mere rotation outward of the foot a matter of minor moment.

When both bones of the forearm are broken, it very often happens that the upper fragments are so rotated by the action of the muscles inserted into them, that union takes place with the axes of the respective portions in a changed relation; the result is that either pronation or supination, or both, may be materially interfered with; and if to this be added any degree of angular deformity, the usefulness of the member may be lamentably impaired.

In all our consideration of the skeleton, whether in its normal condition or as modified by injury, each of its parts must be regarded, not only by itself, but as a member of a system. A deformity of the forearm affects the functions of that portion of the limb primarily, and secondarily interferes with the use of the hand. This secondary disability may be, and generally is, of vastly more consequence than the primary. It is true that in many cases there is ultimately acquired, by means of compensatory motions in other joints, a closer approximation to the original function than might at first seem possible; but this cannot be counted on, and is apt to be neither satisfactory to the patient nor creditable to the surgeon.

There remains to be considered the *lateral deformity*, the chief effect of which is to shorten the bone; and perhaps this will be the most convenient point at which to speak of certain recent observations which have altered the views of surgeons both as to the importance of this matter, and as to the possibility of correctly appreciating shortening in any given case.

Shortening may be caused, in fractures of the long bones, either by malposition of the fragments, and especially by their overlapping each other; or by loss of fragments, as in compound comminuted fractures, where it may be that portions are so wholly separated as to demand immediate removal lest they should act as foreign bodies, or where portions may become necrosed and call for extraction during the later progress of the case; or lastly, by the absorption of the bony substance of the ends of the fragments. The latter occurrence is probably rare, but there is abundant evidence of its possibility, and it may be that it is sometimes an unsuspected element in the apparently unaccountable loss of length in fractured limbs.

The question, whether or not shortening is an unavoidable consequence of fractures of the long bones, has been discussed with much zeal; some surgeons claiming that under proper treatment it ought not to occur, and others insisting that no care or skill can prevent it. It would not, however, be worth while to quote opinions on this point, since recent researches have clearly shown that absolute equality between the two limbs of a pair, or between corresponding bones, is not the uniform rule.

From observations recorded by Hunt, Cox, Wight, Roberts, Garson, and

Dwight,¹ it would seem that the difference is never very great, but varies within somewhat narrow limits. Garson measured carefully the lower limbs of 70 skeletons, of various ages from 12 years upwards. He found that only seven, or 10 per cent. of these, had right and left limbs of equal length, and in two cases only did the femur and tibia of one side correspond respectively to the femur and tibia of the other. In the remaining five cases it was by compensation that the limbs were equal; the tibia being shorter where the femur was longer, or *vice versa*. He found the tendency to variation greater in the femur than in the tibia. In 25 instances, or 35.8 per cent., the right limb was longer than the left, the average difference being 3.3 mm. In 38 instances, or 54.3 per cent., the left was longer than the right, the average difference being 4.8 mm. The left limb, therefore, was not only more frequently longer than the right, but the difference between the limbs was greater, on an average, when it was the longer than when the right was the longer, the greatest difference in the latter case being 8 mm., whereas in the former it was 13 mm. Over the whole 70 cases, the left limb was 1.5 mm. longer than the right. On farther analyzing the differences:—

“We find that in 41 cases the left femur is longer than the right, and in these its average preponderance is 3.8 mm.; in 20 cases the right is longer than the left, the average preponderance being 2.9 mm.; and in 9 cases the bones are equal. Again, in 24 cases the left tibia is longer than the right, the average preponderance being 3.0 mm.; in 29 cases the right is longer than the left, the average preponderance being 2.6 mm.; and in 7 instances the bones are equal.”

Garson hints at a very important matter, which will probably have already occurred to the reader—that there may be inequalities between the ossa innominata of the right and left side, which may be either compensatory or otherwise as regards the unequal lengths of the corresponding limbs. This point, which has not yet been at all satisfactorily investigated, would obviously affect the bearing of the results above quoted upon the surgical measurements of limbs as ordinarily made, from the anterior superior spines of the ilia to the inner malleoli.

Dwight says, in regard to the clavicle, that he found only six pairs equal out of 22 cases examined by him. The greatest difference noted was .39 of an inch. In all but two of the cases of inequality, the left clavicle was the longer.

It must not, however, be inferred that the correction of shortening likely to result from fractures of the long bones is a matter of small importance, or that the surgeon will be justified in neglecting it when called upon to treat such injuries. On the contrary, careful attention should always be paid to it; measurements should be made from time to time, especially during the earlier period of each case, and suitable means adopted for overcoming any tendency to overlapping of the fragments.

When shortening occurs from loss or absorption of portions of bone, it is of course wholly unavoidable. In the former case, the fact of the loss will be known, and in the latter it may be inferred from the absence of overriding; the fragments will be in proper relation, and even if at first there is some exuberance of callus, the bone will eventually be almost normal in shape.

Shortening is, indeed, under any circumstances, of much less moment than angular or rotary displacement, either of which must very gravely affect the

¹ Hunt, Phila. Medical Times, Jan. 16, 1875, and Am. Journ. of the Med. Sciences, Jan. 1879; Cox, Am. Journ. of the Med. Sciences, April, 1875; Wight, Arch. of Clin. Surgery, Feb. 1877, and Proc. of the Med. Soc. of the County of Kings, 1878; Roberts, Phila. Med. Times, Aug. 3, 1878; Garson, Journal of Anat. and Physiology, July, 1879; Dwight, Identification of the Human Skeleton, Boston, 1878.

usefulness of either the upper or lower extremity. The effects of such deformities, as well as the means of detecting and overcoming them, will be pointed out in connection with special fractures.

GENERAL TREATMENT OF FRACTURES.

The broad principles of the treatment of fractures are very easily laid down : to restore the normal relation of the fragments as early and completely as possible, and to adopt the best means of keeping them so until their union shall have been accomplished. But in the application of these principles a vast number of details must be taken into account, and the circumstances may vary so widely as to make what would be good practice in one case wholly improper in another. Without attempting to enumerate all these details, or all the different conditions arising to modify treatment, I shall mention briefly such leading matters as concern the surgeon in dealing with this class of cases ; in regard to those of minor importance, experience and common sense will be his best guides.

FIRST ATTENTIONS TO THE PATIENT.—Occasionally, when it is one of the bones of the upper extremity that is broken, the patient comes to the surgeon's office. More frequently, the latter is sent for after the sufferer has been taken home, or to the place where he is to be treated ; and sometimes, especially if the injury is severe, or if it affects a lower extremity, the surgeon's first services are rendered at the scene of the accident, or in some neighboring house.

Circumstances must determine whether the exact character of the injury shall be ascertained at once, or after the patient has been removed to his room, perhaps to his bed. If there be much suffering, or shock, it may be better to adopt temporary measures for the relief of these conditions, especially if the distance to be gone over is considerable. By a careful and gentle handling of the limb complained of, over the clothing, a general idea may be acquired of the seat and character of the injury ; but if there be a compound fracture a more thorough examination should be instituted, lest bleeding or some other complication demanding relief should be present. Perhaps it is unnecessary to say that the surgeon's manner should be firm, calm, and reassuring, and his manipulations carried on with a steady and gentle hand. Shock may be combated by stimulants sparingly but frequently given ; pain generally subsides upon the application of proper temporary dressings. These may be made out of simple or even rude materials ; an old blanket and two or three shingles or barrel-staves, or even a mere truss of straw, may be so bound around a broken leg or thigh as to give it support and comfort until more suitable appliances can be had.

The transportation should be arranged for by the surgeon, and, in bad cases, effected under his eye. If it is to be done by hand, it is best to have the bearers of about equal height, if possible, and, in lifting the patient on to the stretcher or other means of conveyance, the surgeon should himself take charge of the broken limb. The bearers should *not* keep step, as this results in a regular swaying motion, which sometimes gives great pain at the seat of fracture ; they should, however, walk as evenly and steadily together as possible.

The best form of wheeled vehicle, for fractures of the lower extremity, is a wagon, into which the stretcher can be lifted with the patient upon it. For cases affecting the arm, a carriage does as well ; the injured limb should be carefully placed in a sling, and steadied with the patient's other hand.

Arrived at the place of destination, the surgeon should see the room in

which the patient is to lie, and the approaches to it, and should so direct the bearers that there shall be no awkward changes or turnings to be made in reaching it. The best kind of bed is a narrow one, with a firm mattress on top; it makes very little difference whether there are feathers, straw, or springs below, provided that they give a good and equable support. The surgeon still taking charge of the injured limb, the patient should now be lifted firmly, promptly, and gently, and laid on the bed in such a position that the fracture can be gotten at with facility for the purposes of examination and dressing. It will readily be perceived that all these manœuvres will be much easier in the case of a child, a light person, or one who can help himself somewhat, than under opposite circumstances; they may present extreme difficulty if the patient is very heavy, or otherwise infirm and helpless.

Sometimes, as already said, all this has been done before the arrival of the surgeon; or the accident may have taken place in or close by the patient's house. In either case, the next step is to remove the clothing, and examine the injury. Often it is better simply to rip or tear the clothing away; but to poor people this may be a serious affair, and one to be avoided if possible. Under such circumstances everything should be loosened, and the sound arm or leg first stripped, when the rest is an easy matter. Too often the patient is needlessly exposed, and may take cold; he should be at once covered up with blankets or any other convenient wraps.

The surgeon should next carefully examine into the nature and extent of the injury, if he has not already done so. If his previous investigation has satisfied him on these points, he may keep the temporary dressings in place until he has prepared those which he intends to apply. Not unfrequently anaesthesia is required to facilitate this inquiry, as well as the correction of displacement—the setting or reduction of the fracture. Much pain may be thus saved to the patient, and the surgeon's task is rendered easier by the abolition of muscular resistance.

REDUCTION.—It is now an established rule in surgery, that the reduction of a fracture should be effected at the earliest available moment. Otherwise the muscles become shortened, and not only the difficulty of the procedure itself, but the risk of inflammation and of other unpleasant symptoms, from the pressure of the fragments upon vessels or nerves, may be rendered much greater.

The process of setting or reduction consists simply in the overcoming of whatever displacement of the fragments may be present, and restoring the normal shape of the bone as accurately as possible. Very generally the deformity, as mentioned in a preceding page, is somewhat complicated; so that the broken ends may have overlapped, or may be engaged together by their irregularities, and at the same time not only placed at an angle, but rotated in reference to one another. When there are two bones, as in the forearm or leg, and both are fractured, it will readily be seen that the different fragments may become so entangled, either with one another or with the interosseous membrane, as to present a condition equally difficult to recognize and to correct.

In some cases a broken bone may be set with scarcely any trouble to the surgeon, or pain to the patient; but occasionally—rarely, it is true—the displacement cannot be corrected by any available means. Between these two extremes there are innumerable gradations. The amount of difficulty encountered is by no means proportioned directly to that of displacement; on the contrary, a very slight change in the relation of the broken ends may be so maintained by the interlocking of their serrations as to baffle every effort

of the surgeon to disengage them. Especially is this apt to be the case when the fracture is situated close to a joint, so that one of the fragments is too small to afford much purchase. Sometimes the difficulty may be due to the entanglement of one fragment in a tendon, looped, as it were, around it.

On the other hand, if the deformity is easily reduced, it is apt to recur with equal readiness. Very oblique fractures of the shafts of the long bones can generally be drawn into place without much trouble; but the causes of displacement have like facility of action, and a certain amount of shortening is almost sure to result. Fractures of the radius near the wrist, those of the femur near the knee, and those of the leg near the ankle (not in either case entering the joints), are very difficult to reduce, the first named especially; and they are often, no doubt, only partially brought into place; yet, when this is once accomplished, very simple retentive means will suffice to obviate the recurrence of the displacement.

Under all circumstances it should be borne in mind that the fragments can only be restored by reversing the process of their displacement; they must go back by the same way by which they came into their false position. And it is of the utmost importance that the surgeon should know that the reduction is complete; it is not enough that the outward form of the limb is restored, for this is sometimes deceptive. The soft parts may be pulled and stretched, and the swelling may mask the deformity, while the false relation of the fragments remains unchanged. Hence the most rigid examination should be made during and after the efforts at replacement, and the exact condition of things should be determined. If restoration be found to be impossible, the fact ought materially to influence the prognosis given to the patient and his friends.

An essential part of the process of reduction, in most cases, is the making extension and counter-extension. In children, or with the smaller bones of adults, the surgeon may often accomplish this with his own hands, grasping the limb above and below the seat of the injury; at the same time with his thumbs he can push the fragments into position. But in larger limbs, and in all the more difficult cases, it is better to have one or two assistants to apply this extension, while the surgeon has both hands free to mould and knead the fragments. Rotary and angular displacements are to be corrected at the same time that extension is made, the sound limb being taken as a guide for the normal shape, and certain lines and landmarks, to be hereafter mentioned, being kept in view as tests of the accuracy of the restoration.

Some differences of opinion have existed as to the best way of making extension, whether the force should be applied as far from the fracture as possible, or close to it. The true rule would seem to be that in each case the surgeon should be guided by circumstances. In very muscular and closely knit limbs, as, for instance, in a fracture of the thigh in a powerful adult, it may be found necessary, in order to make extension, for one assistant to put the bend of the left elbow under the patient's knee, and with his right hand grasp the patient's ankle, flexing the leg; while, for counter-extension, another assistant may either have a towel or sheet folded and applied to the perineum, the ends being tied around a stout stick for him to grasp, or he may, if very strong, clasp his own hands together over the perineum. In loose-jointed patients, traction at a distance from the fractured bone may simply put the ligamentous structures on the stretch; but in such persons there is apt to be less muscular resistance to reduction.

With regard to the process of measurement, and the points from and to which measurement is to be made, details will be given in connection with the fractures of special bones.

DRESSING THE FRACTURE.—Reduction having been effected, with the aid of an anæsthetic if necessary, the next thing is to secure the fracture, so that the healing process shall go on undisturbed, with the broken ends in their restored relation. Countless contrivances have been brought forward for this purpose, some costly and complicated, some cheap and simple. I have no hesitation in advising against the use of the former. The best results can be obtained with the simplest means, applied with such dexterity as every surgeon ought to have, with a clear idea of the object in view, and watched with conscientious care. Without such intelligent skill and care, the most elaborate and expensive apparatus may fail to answer the purpose.

Splints and *bandages* are very extensively used in the treatment of fractures. Various materials are used for the former: wood, binders' board, leather, felt, tin, sheet-zinc, wire-netting, and wire frames. Of these, wood has been most extensively employed, generally thin strips of white pine or deal, which should be shaped to fit the limb in every case. Scarcely any of the carved splints sold in the shops are suitable for use, as they are not made with a proper knowledge of anatomy, and must be altered by the surgeon. Dr. Jacob, of Dublin,¹ recommended strips of the bark of trees, cut when the sap was rising, for splints for fractures (in children especially); and Dr. Grant,² of Ottawa, Can., speaks highly of spruce shavings as a material for the same purpose. Binders' board, cut in the requisite shape, and softened in hot water, may be moulded so as to fit well, and becomes very hard on drying; and the same may be said of gutta percha, of thick leather, and of felt. Tin is much less manageable, but can be adapted to some cases, if the surgeon can succeed in giving the proper measurements to the tin-smith. Sheet-zinc has no special advantage over tin, although M. Raoul Deslongchamps has extolled its virtues in a volume of several hundred pages. Wire netting is sold in sheets, and can be cut with suitable pliers; but it is generally prepared for use by the addition of a thick wire frame around the edges. Wire splints can be better described in connection with the special fractures for which they have been most extensively employed. Splints, of whatever material, should always be of exactly the proper size and shape. If too small, the edges may cut into the skin; if too wide, and especially if loosely put on, they will not give due support to the limb, nor prevent the displacement of the fragments. When wood, binders' board, or gutta percha is used, it is a good plan to bevel the edges all around, at the expense of the inner face, lest they should come in contact with the skin and irritate it, in spite of the most careful padding.

Bandages are best made of unbleached muslin, of medium weight, not too closely woven. They may be from two to three inches wide, and about six yards in length. They are rolled up for use, as described in the article on Minor Surgery.³

In former times, a custom prevailed of applying what was known as an "immediate" bandage to a fractured limb, in order, as was supposed, to prevent muscular contraction. This custom has now been generally abandoned, although it is still followed by some practitioners; it never can do any good, and may do much harm.

For the purpose of protecting the skin, and better adapting the pressure of the splints to the irregularities of the surface, padding is always employed. Raw cotton is the material generally chosen; it should be clean, fresh, evenly torn, and in sufficient quantity. Carded wool answers quite as well, and even better if it cannot be frequently changed, as it does not become lumpy and sodden

¹ Am. Journ. of Med. Sciences, Jan. 1847; from Dublin Med. Press.

² British Med. Journal, Jan. 14, 1882.

³ See Vol. I. p. 489.

with perspiration, as cotton does. An excellent substitute, almost always at hand, when neither cotton nor wool can be had, is found in flannel; three or four thicknesses of old blanket make a very efficient and agreeable lining for any kind of splint. Some surgeons use the article known as "canton flannel" in the same way; the soft or flocky side should always be placed in contact with the skin.

By Tufnell,¹ the use of long bags of straw, as combined splint and padding, has been recommended; the straws are carefully arranged lengthwise, and the sacks are not so tightly stuffed but that they can be shaped by pressure to fit the limb. This plan, which certainly has merit, has never come into general use.

Allied to these, but of less value because less adaptable, are various forms of cushion and of padded apparatus, which do not seem to me to need description. For merely temporary support and protection, an ordinary pillow may sometimes be applied with advantage. Sand-bags are often of great use, and will be further referred to hereafter.

Water-cushions have been proposed by Jeaffreson² and by Thompson³ as substitutes for padding, but have never been generally employed, and are certainly open to very decided theoretical objections, apart from their costliness. The same may be said of the air-pads of caoutchouc, devised by Gariel.⁴

Solidifying Dressings.—The employment of bandages imbued with materials which harden on drying (such as gum shellac or other gummy or resinous substances), is of very ancient date. But it had almost entirely gone out of fashion until Larrey, about 1825, revived the idea, using the bandage of Scultetus, and cushions or compresses soaked in a mixture of spirit of camphor, acetate of lead, and the whites of eggs. The apparatus thus made was allowed to remain until consolidation had taken place.⁵ Some ten years later, Seutin proposed the substitution of starch for the composition above mentioned, as well as for plaster moulds, which had been used by Dieffenbach, and probably long before his time. Seutin, however, modified the plan by suggesting the division of the splint with pliers, after the lapse of a few days, not only in order to examine the state of the limb, but to refit the apparatus and insure its effectiveness. By so doing he made this method what it has been ever since, although the materials used for stiffening have been variously modified by different surgeons. Glue, paraffine, gum arabic and whiting, flour and white of egg, plaster of Paris, silicate of potassium or sodium, in different combinations or alone, have been thus used. Of all these, the best are probably the two last named, as they are cleanly, and the solidification takes place so quickly as to make them much more secure than those which "set" only after a length of time. Tripolith, a material recently employed in Germany as a substitute for plaster of Paris, is said⁶ to be lighter than that substance, to harden more quickly, to be non-absorbent when once dried, and to be a trifle cheaper. Its exact composition is unknown, and I am not aware of its ever having been brought to this country.

The silicate of potassium may be bought in saturated solution of any wholesale druggist; it is applied with a clean bristle-brush, such as house-painters use, to successive layers of bandage after they are put upon the injured limb, the skin being carefully protected by a smooth and even layer of raw cotton. I have thought it well to lay two or more strips of thick

¹ Am. Journ. of the Med. Sciences, Jan. 1847; from Dublin Med. Press.

² Lancet, Nov. 9, 1867.

³ British Med. Journal, April 10, 1880.

⁴ Jamain, *Petite Chirurgie*, p. 210. Paris, 1860.

⁵ *Journal de Progrès*, etc., tome iv. 1827.

⁶ Med. Times and Gazette, Nov. 27, 1880.

muslin along the sides of the limb, one over each layer of bandage, to act as side-splints. During the application the limb should be kept in proper position by assistants grasping it above and below. Generally in about ten minutes the silicate becomes so firm that the limb may be safely laid on a pillow.

Plaster of Paris may be employed in the same way, the dry plaster being sifted into a basin of hot (or cold) water, and applied with the hands of an assistant as the surgeon puts on the bandage. The latter should be loose-meshed (what is sold in the shops as cheese or dairy muslin answers very well). The mixture is ready for use as soon as it begins to assume the consistency of thin cream; it takes rather longer to set than the silicate does. Whichever material is used, a narrow space may be left along the back (under surface) of the limb, along which in a few days the bandage may be split up with a pair of strong scissors, for the purpose of examination; and thereafter we have a moulded splint, which may be simply reapplied and kept in place by a fresh roller of bandage-muslin.

Another way of applying plaster of Paris is by means of loose-meshed bandages, filled with dry plaster, loosely rolled, and dipped into water just before they are used. In hospitals, or where these are extensively employed, it is worth while to have an apparatus¹ for imbuing the bandages with the plaster; and they should be kept in close tin boxes, or wrapped in waxed paper. To divide a plaster bandage put on in this way, the saw or pliers must be used.²

Still another method is known, in its best form, as the Bavarian. It consists in cutting two pieces of stuff (shrunk flannel is the best) a little more than wide enough to encircle the limb. Two rows of stitches, about an inch apart, are now carried along on either side of the middle line, so as to fasten the pieces together. The cloth now being laid under the limb, the two upper flaps are brought together above and stitched, thus encasing the limb. Next the other flaps are evenly spread with the mixed plaster, of about the consistency of thick cream; and these being brought up into place are also sewed together, and the spare stuff is cut off. The limb is thus encased within two double layers of flannel, which, by the setting of the plaster between them, will form a very firm support on each side. A roller over all will serve to reinforce the stitching, and keep the whole in place.

A somewhat similar arrangement has been proposed³ by Mr. Jordan under the name of "laminated plaster splints." He uses six or seven layers of muslin, with plaster of Paris spread evenly between them with a spatula; they are then dipped in water and applied. A flannel bandage, or layer of cotton wadding, is put next the skin.

Some surgeons advocate the insertion of strips of tin between the layers of the plaster bandage, in order to give it strength; and in the case of very large and heavy limbs this might be desirable, as it would largely increase the firmness of the apparatus without adding materially to its weight. Ordinarily, however, it would be needless.

Paper splints, the material being saturated with starch, and applied in layers until the requisite thickness is obtained to give firm support when dry, were first suggested by Laugier.⁴ The idea has since been repeatedly brought forward anew by others.

When the *fracture is compound*, the wound must of course be left uncovered for the purpose of applying suitable dressings. This may be done either by cutting the bandage as it is put on, when the proper point is reached, and beginning afresh at the other side of the gap; or by cutting a hole in the apparatus after it is finished. The former is the preferable plan; the plaster

¹ See Vol. I. p. 504.

² British Medical Journal, July 15, 1882.

³ Ibid., p. 499.

⁴ L'Expérience, 1 Août, 1844.

holds the cut ends of the bandage securely. The other method may involve some pain to the patient. In order to prevent soiling of the plaster-dressing by discharges, etc., it may be well coated, when dry, with copal or other varnish.

Some surgical writers recommend the insertion of hooks or staples in the plaster apparatus for the purpose of suspension of the limb; but a better and more secure arrangement for this purpose can be made by means of supplementary wire frames, in a manner to be described hereafter.

AFTER-TREATMENT OF FRACTURES.—No apparatus which will exercise rigid pressure should ever be applied to a recently broken limb, if there is much contusion, swelling, or ecchymosis. Mischiefs may thus arise in a very few hours, which may even cost the patient his limb and the surgeon his reputation. Fractures should always be carefully watched for the first few days, and should never be neglected at any stage of the treatment. And here I must enter a protest against what seems to me a most dangerous maxim, though it has received the sanction of some high authorities, namely, that "comfort is the sign that a fracture has been properly dressed." It is true that, as a general rule, a fracture properly dressed ceases to be painful; but it is also true that a fracture may cease to be painful although none of the indications for its proper treatment have been fulfilled. The fragments may be in very bad position, the deformity wholly uncorrected, and yet the patient be free from suffering. I have seen a man with a fracture at the middle of the leg, in the third week, lying at his ease in bed, with the foot completely everted, so that the toes pointed almost directly outward; and could cite many other cases, although, perhaps, not so marked. Actual inspection carefully made, at sufficiently frequent intervals, can alone guard against bad results; the whole limb should be examined, and nothing be left to the chance of all being right.

Fractures of the lower extremity, as a general rule, involve a long confinement to bed—those of the thigh always, and, in hospitals, those of the legs also. In private cases, I have for some years been accustomed to use such appliances for swinging broken legs as to enable the patient to sit up almost from the very first.

One of the annoyances of such confinement consists in the difficulty experienced in having the bowels moved without disturbing the fracture; and to obviate this much ingenuity has been expended in the devising of different forms of "fracture-bed." The one in common use in our hospitals is merely a mattress perforated in the centre with a round hole, filled up with a pad, except when the bowels are to be moved, when the pad is taken away and a chamber-pot put below the opening. The lower sheet must, of course, be perforated in the same way. Others have various arrangements of sections sliding in and out; and still others are made so that the patient lies on a perforated sheet of canvas, stretched on a frame, which can be raised by a mechanical contrivance, so as to allow of the vessel being pushed in under the nates. The best-known apparatus on this principle is that of Jenks, in which strips of canvas are substituted for the perforated sheet. In hospitals, where the services of assistants can always be had, the frame can be lifted by handles, like a stretcher. Except, however, in the case of fracture of both femora, these contrivances possess hardly any advantage over the common bed-pan, if the latter be carefully and skilfully used. I will therefore merely mention the fracture-beds of Earle,¹ Daniels,² Burge,³ Crosby,⁴ Pancoast,⁵

¹ Practical Observations in Surgery, p. 135. London, 1823.

² Hamilton, *op. cit.*, p. 474.

⁴ Hamilton, *op. cit.*, p. 475.

³ New York Journal of Medicine, May 1, 1857.

⁵ Gross, *op. cit.*, vol. i. p. 1029.

Gariel,¹ Rabirot,² and Pouillien.³ By reference to the work of Richter,⁴ it will be seen that the ingenuity of German surgeons had been early exercised in the same direction, and with very analogous results.

Two objections hold against every form of perforated mattress. One is the tendency to flattening down of the stuffing toward the central hole, so that the hips of the patient come at length to rest in a hollow; this being, of course, especially likely to happen where the same mattress is used over and over again, as in hospitals. The other is the difficulty of avoiding the soiling of the edges of the opening, which requires careful attention whenever there is an evacuation either from the bowels or from the bladder. Yet these objections are not fatal, as they can be set aside by care in making and using the mattresses, as well as in their proper renovation from time to time.

Patients who are obliged to lie in bed, are often greatly relieved by even a very slight change of posture, from the shifting of the bearing-points of the body. A very old contrivance, mentioned by Turner,⁵ may be used with advantage to facilitate this; it consists in a strong cord attached to any convenient point above (a frame connected with the bed, or one of the joists of the room), and having its lower end hanging free, with a stick fastened transversely across it so as to serve as a handle by which the patient can raise, turn, and shift his body.

Many other forms of apparatus are employed in the treatment of fractures—such as fracture-boxes, inclined planes, means of making extension and counter-extension, and appliances for suspension—which may be more conveniently described in connection with the special cases for which they are designed.

The general rule may be laid down, that in fracture near a joint the dressing should be arranged so as to immobilize that joint; and that in fractures of the shaft of a bone the joints above and below the seat of injury must be secured. And for the first week at least—in many cases for a much longer period—the whole limb should be kept at entire rest. Large, long, and heavy limbs, in which there is a good deal of leverage on the fragments, require more protracted confinement than small and light ones. Sometimes, as in fractures about the wrist, and in those of the lesser bones generally, the patient can be safely allowed, after the first few days, any degree of freedom of motion which does not involve pain.

Passive motion may, in my opinion, be resorted to much earlier than is the usual practice, and with great advantage; as soon, indeed, as all inflammatory symptoms have altogether subsided. In the case of the upper extremity, no assistant is needed; the surgeon may, at each removal of the apparatus, grasp the fractured portion very firmly and gently with one hand, while with the other he very cautiously flexes and extends each joint in turn. When the fracture is in the lower limb, the surgeon may use both hands to control the broken bone, while a trustworthy assistant impresses motion on the joints. Gradually, as time goes on, this process may be more and more freely carried out. Properly managed, it is productive of no pain, and goes far toward preventing the stiffening which is sometimes a very troublesome sequence of these injuries. No force should be used at any time. There are cases in which the fact of difficulty in manœuvres of this kind is important as an indication that the fragments are not in proper position.

During the later stages of the treatment, after consolidation has begun to be perceptible, it is well to add to this passive motion sponging of the limb

¹ Jamain, op. cit., p. 319.

² Ibid., p. 320.

³ Ibid., p. 322.

⁴ Theoretisch-praktisches Handbuch der Lehre von der Brüchen und Verrenkungen der Knochen. (Text und Atlas). Berlin, 1828.

⁵ The Art of Surgery, 2d ed., vol. ii. p. 161. London, 1725.

with soap and hot water, to which, for persons of relaxed fibre especially, some whiskey or spirit of camphor may be added. This is not only agreeable to the patient, but, I believe, is positively beneficial.

As the union of the bone becomes more and more firm, the muscles of the limb may be stimulated by gentle friction and pinching, in order to prepare them for the renewal of their functions.

Fractures of the lower extremity must be allowed to become perfectly consolidated before the apparatus is left off, and then the limb must be accustomed by degrees to the dependent position before any attempt is made to bear weight upon it. A patient will sometimes use crutches for a few days, and feel his way, as it were, until he finds that he can support himself upon the repaired member. In the case of the upper extremity, as the bone becomes more and more firmly united, the splint may sometimes be cut off piece by piece at either end, so as give the limb gradually increasing liberty; and in this way the use of the hand may be almost imperceptibly regained. Care and judgment are as necessary in these latter stages as in the very first attentions to the case.

In fact, each portion of the treatment of a case of fracture has its own duties for the surgeon, and its own risks for the patient. At first, the reduction and the dressings must be carefully, thoroughly, and skilfully executed; while the process of union is going on, attention must be given to keeping up the proper relations of the fragments; and towards the end, the safe and complete restoration of function must be provided for. At any of these stages, neglect may be disastrous.

As to the treatment of the *complications* which may arise in a case of fracture, very little need be said. These intercurrent disorders should in general be dealt with as under other circumstances; they may assume such importance (*e. g.*, tetanus or pyæmia) as to overshadow entirely the local injury. The management of *compound fractures* may be best described in connection with the fractures of the several bones, as it differs in different regions of the body.

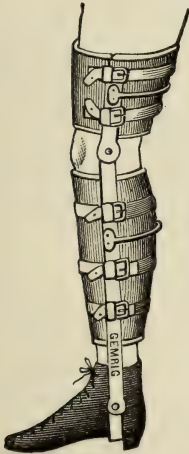
TREATMENT OF DELAYED UNION AND FALSE JOINT.—When the surgeon finds that the fragments are still movable upon one another at the end of the time when union might reasonably be expected, he should consider whether any constitutional defect or disorder exists, or any local condition, to which the failure can be attributed; and if such hindrance can be discovered, appropriate treatment must be instituted. Should the patient be a pregnant woman, otherwise healthy, she may be encouraged to hope that the bone will knit after her confinement shall have taken place.

As a general rule, the use of a solidifying dressing is most distinctly indicated in these cases; and my own choice is always either the plaster-of-Paris or the silicate-of-potassium bandage. It should be applied with the utmost care and accuracy, so as to keep the fragments absolutely in place, the whole limb being encased in it; and it may be left undisturbed for a much longer time than would be safe at an earlier period. On its removal, after the lapse of three or four weeks, if no change can be detected, the two portions of the limb should be firmly grasped, and the fragments rubbed together with some force, until some pain and soreness are induced. The apparatus should now be re-applied, as carefully as before, and kept on for perhaps two weeks, when the parts may be examined, and the rubbing repeated if necessary. Should there be absolutely no increase of firmness, the friction may be employed daily, with shampooing or massage of the whole limb, for three or four days; or the skin may be stimulated by a blister, or by painting it with tincture of

iodine. After this the immovable apparatus may be again put on for three or four weeks.

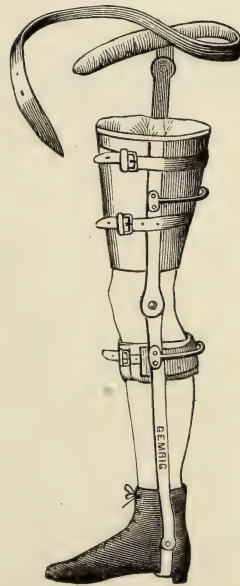
During all this time the strength of the patient should be supported and improved by nutritious diet, with tonics if need be. Certain remedies have long been supposed to have a direct effect in promoting the formation of callosus. Thus the phosphate of lime and the carbonate and phosphate of magnesium, have been credited with hastening union in some cases. Probably the "osteo-colla," or "ossifrage," recommended by Hildanus, and spoken of by Turner¹ as used both internally and externally—a stone found near Darmstadt in Germany—was composed mainly of these salts. Milne-Edwards² found by experiments on dogs that the phosphate and carbonate of lime given internally promoted the healing of their fractures; and quotes the favorable experience of Gosselin with the same drugs, in man, given in the dose of half a gramme (about 8 grains) thrice daily. Fletcher³ gives six cases of remarkably early union, in persons to whom lime-water and chalk-mixture had been administered. Gurlt quotes from Saucerotte a case in which a *tisane* of madder is said to have produced, in two months, union of a fracture of the leg which had been three months unhealed. Hammick⁴ says, that "mercury will frequently be required by patients who never had any syphilitic taint, not only to act as an alterative, but even it will be necessary to push it to a considerable extent before union of a fractured bone will take place." He

Fig. 808.



Smith's apparatus for ununited fracture
of the leg.

Fig. 809.



Smith's apparatus for ununited fracture
of the thigh.

quotes a case in point, and says that "this so commonly occurs, that it will not be necessary to trouble you with the detail of any more cases in confirmation of it." As my own experience in regard to the medication of cases of delayed union has never gone beyond the use of tonics, and of anti-

¹ Op. cit., vol. ii. p. 153.

³ Lancet, 1846.

² Am. Journal of the Med. Sciences, Oct. 1856.

⁴ Op. cit., p. 118.

syphilitic remedies in some cases where there was suspicion of a venereal taint, I quote the foregoing statements, without comment.

In the great majority of cases of delayed union, perseverance in the line of treatment now laid down will be rewarded by success. When three months have elapsed, if there is not an encouraging increase in the firmness of the union, the patient may be allowed some use of the limb, with the safeguard either of the plaster bandage or of a prothetic apparatus, such as that devised by Dr. H. H. Smith¹ (Figs. 808, 809). This consists essentially of a jointed splint composed of steel bars, with padded straps to confine it to the limb. Success has also been reported² to have been obtained by the use of tourniquets applied so as to exert slight pressure over the seat of fracture. Percussion by means of the fist or a hammer, the limb being protected by a padded leather splint, was proposed several years ago by Thomas, of Liverpool, and has lately been reported on favorably.³ Electricity⁴ and galvanism⁵ have been occasionally employed with apparent benefit.

Gurlt⁶ speaks with commendation of the forcible tearing asunder of the uniting medium, the patient being of course placed under an anæsthetic, and the operation so performed as to involve nothing but the fibrous bands holding the fragments together.

The modes of procedure thus far mentioned have been such as involve no wounding of the skin, which for obvious reasons it is better to avoid if possible. Sometimes, however, it is expedient to use means which shall directly affect the ends of the fragments, or the intermediate tissue. Thus *stimulating injections* were used in 1833, by Hulse,⁷ with success. Another case was reported by Bourguet;⁸ but here a silicated apparatus was also applied, and phosphate of lime was given internally.

Subcutaneous puncture, first recommended by Miller,⁹ has been successful in my hands, in a case of false joint in the thumb, in a child;¹⁰ it is particularly adapted to this condition, but I have seen no other cases reported except two referred to by Hamilton.¹¹ It consists simply in passing a narrow-bladed knife between the fragments, and scoring their ends with its edge, so as to freshen them up; in my case, I used a cataract needle. *Electro-puncture* is said by Azam¹² to have yielded a good ultimate result, although at the expense of extensive and long-continued suppuration, indicating an amount of risk to which most surgeons would hesitate to subject patients, in order to obviate a mere inconvenience.

The *seton* was first employed by Physick in 1802, in a case of ununited fracture of the humerus,¹³ and for many years was by far the most efficient means of obtaining union; the list of reported cases in which it has been used would be too long to cite. It was kept in place for varying periods, from a few days to many months. Somme, of Antwerp, wishing to affect a

¹ Am. Journal of the Med. Sciences, Jan. 1848. The idea was not new, having been successfully carried out by White in 1768.

² Ibid., Nov. 1834.

³ Jones, Medical News, Nov. 18, 1882; from Lancet, Oct. 28.

⁴ Lente, New York Med. Journal, Nov. 1850.

⁵ Burman, Am. Journ. of the Med. Sciences, April, 1848, from Provincial Med. and Surg. Journal, December 1, 1847.

⁶ Op. cit., Bd. i. S. 652.

⁷ Am. Journ. of the Med. Sciences, Feb. 1834.

⁸ Ibid., April, 1874, from L'Union Médicale, 10 Fev.

⁹ Principles of Surgery, Am. ed. 1845, p. 503.

¹⁰ Am. Journ. of the Med. Sciences, July, 1875.

¹¹ Op. cit., p. 81; Trans. of Am. Med. Association, 1850.

¹² Mém. et Bull. de la Soc. Méd.-Chir., etc. de Bordeaux; review in Am. Journ. of the Med. Sciences, Jan. 1868, p. 180.

¹³ Medical Repository, New York, 1804; Am. Journ. of the Med. Sciences, Nov. 1830.

larger surface, passed a wire loop between the fragments.¹ At present the seton has been abandoned in favor of more certain methods; it was not free from danger, and I have myself witnessed a death from its use.

Drilling of the fragments has been practised by many surgeons, with a large measure of success; it may be done with an ordinary gimlet, although various forms of more surgical-looking instruments have been devised for the purpose. Fig. 810 represents that employed by the late Prof. J. Pancoast:

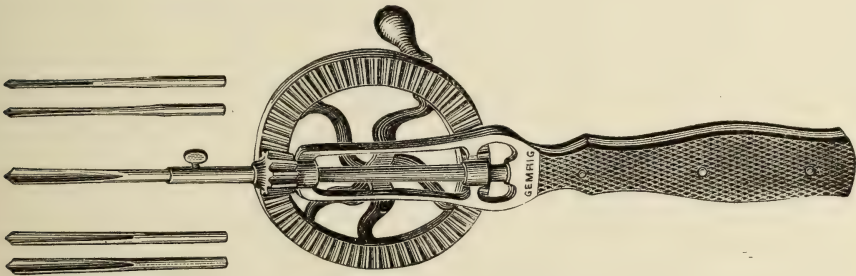
Fig. 810.



Pancoast's screw for ununited fracture.

and Fig. 811 a more complex, but very convenient instrument, invented by Mr. T. Gemrig. Dieffenbach's plan of introducing *ivory pegs* into the holes thus made in the bone, enjoyed for a time a high place in surgical esteem, and

Fig. 811.



Improved drill for ununited fracture.

has not yet been wholly given up. Bickersteth² is said to have described, in 1854, a modification of Dieffenbach's process, which proved very efficient; it consisted in drilling the broken ends, and nailing them together with ivory pegs. Anderson³ reports a case in which the pegs were not removed for four months, and quotes from Trendelenburg one in which they were allowed to remain for a year and a half. From an observation reported by Riedinger to the tenth German Surgical Congress,⁴ it would appear that ivory pegs buried in a human bone need not undergo absorption, but may remain for years without exciting reaction; any portion, however, which may project outside of the periosteum, does become absorbed at that level, and drops off.

M. Schede, of Hamburg, recently exhibited to the Congress of the German Society of Surgery,⁵ some *gilt steel needles*, three and a half centimetres in length, and two millimetres in thickness, used with advantage by him in cases of pseudarthrosis. Ten or twelve of these needles are inserted into the softened part of the bone, without any complaint of pain on the part of the patient; an antiseptic dressing is then applied. The needles are kept in place about fifteen days. So far, M. Schede says, this simple and convenient procedure has succeeded in all the cases in which it has been employed.

¹ Med.-Chirurgical Transactions, vol. xvi. 1830.

² Note signed "W. T. C.," Lancet, Dec. 16, 1882.

³ Trans. of Pathological Society of London, 1881.

⁴ Verhandlungen, 1881, S. 167.

⁵ Gaz. Méd. de Paris, Aug. 12, 1882.

Remedial measures such as those now described are suited for cases of delayed union, and for those in which the fragments, although movable upon one another, are yet in relation by somewhat wide surfaces. But they would have failed in the instance, for example, reported by Dorland,¹ in which a portion of muscle was caught between the fragments. Stanley² mentions a like case. They would be equally useless where the fragments were rounded off, walled in at the ends, and connected by well-defined ligamentous bands. Here nothing short of the exposure of the bone, the renovating of the broken ends, and the securing of their apposition, could be of any avail.

Perhaps the indications for such grave interference with the parts may be stated to be, in general terms, the obstinate persistence of mobility, with pain and other evidence of some unusual obstacle to union; or the very great degree of mobility, with subsidence of all swelling, and entire absence of pain or tenderness. In one or two instances I have been able to make out the rounded and atrophied condition of the fragments.

Of the old plans of refreshing the broken ends by means of the *actual* or *potential cautery*, nothing need be said, except that while the probability of their doing good is very small, the possibility of their doing harm by setting up osteo-myelitis is too real to be overlooked. They should be accorded a merely historical importance.

Resection for ununited fracture dates back to 1760, and the credit of it is due to White,³ of Manchester, who practised it with brilliant success in a number of instances. It involves the complete exposure of the fractured ends, which are then freshened by scraping, or by cutting them off on either side with a saw or with bone-nippers. The bone-director (Fig. 812) is very

Fig. 812.



Blandin's bone-director.

useful in turning out the ends to be sawed off. The incision should always be made where the bone is most accessible, and where there is least risk of injury to important structures. Any large vessels or nerves which are exposed, should be carefully held aside with blunt hooks, and the chain-saw will be found more convenient in every way than any other. Listerian precautions may be adopted by those who think that they diminish the danger of such procedures; if they do no good, they will do no harm. As a rule, both fragments should be attacked, although success has sometimes been achieved by section of one only, the other having been beyond reach except by greatly increasing the magnitude and difficulty of the operation, as well as the risk to the patient.

The earlier operators in this direction were content to employ, after the cutting of the bones, a carefully adapted apparatus for retaining them in place. An improvement was introduced by Horeau, in 1805, in the tying together of the obliquely divided fragments by a *metallic wire* carried around them; and a still further advance was made in 1838, by Dr. Rodgers, of New

¹ Canada Med. and Surg. Journal, 1881.

² Dublin Med. Press, Aug. 2. 1854; Am. Journ. of the Med. Sciences, Oct. 1854.

³ Cases in Surgery: London, 1770, pp. 69 *et seq.*

York,¹ in passing the wire through holes drilled in the walls of the fragments, so as to keep them in apposition. Many cases of union brought about in this way are upon record; it is especially applicable where there are two bones, and those very movable, as in the forearm. Dr. H. J. Bigelow² attaches importance to stripping up the periosteum from the fragments, for a short distance, before dividing the bony structure. Other American surgeons who have operated in this way with success are Brainard,³ Byrd,⁴ Jones,⁵ Sanborn,⁶ Ashhurst, and myself.⁷ Cases are also reported by Annandale,⁸ and Renton.⁹ A somewhat more complicated device was employed by Le Moynes,¹⁰ in the shape of a *steel clamp*, drilling and ivory pegs having been previously used without success. Next day the clamp was found to have started from the upper fragment; the wound was therefore reopened, and silver wires placed around clamp and fragments, so as to hold the former firmly in place. Two months after the operation union seemed to be perfect, but the wire and clamp were so firmly held that it was determined to leave them, and the wires were cut off as closely as possible. At the last report, some months afterward, the wound was almost entirely closed.

Hamilton¹¹ speaks of having on one occasion engaged the end of one fragment in the medullary canal of the other, but does not state with what success. Roux¹² did the same, but, although no bad symptoms ensued, a fall at the end of two months caused such fresh injury that the arm was amputated. It would be interesting to know what was the state of the bone which had been so treated.

Nussbaum is reported¹³ to have operated by *transplantation* in a case of fracture of the ulna with loss of substance. He cut a portion two inches long, comprising about half the thickness of the bone, from the upper fragment, and, without severing its fibrous attachments entirely, he shifted it downwards so as to fill up the gap. The result is said to have been entirely satisfactory. Such a procedure could scarcely be undertaken except by a surgeon with shoulders broad enough to take the consequences of possible failure.

Having now passed in review the various plans which have from time to time been employed for the cure of pseudarthrosis, the subject may be dismissed with a few general remarks.

In the first place, the milder measures should be first adopted, where they offer any chance of success. In cases of long standing, where the broken ends have obviously become rounded off, and are completely separated, there may be no reason for delay; and here resection and wiring seems to me to be the safest and most certain of the methods. But in more hopeful cases, after rest and accurate adaptation have been tried, with rubbing of the fragments upon one another, drilling may be resorted to, with or without the insertion of ivory pegs. Failing all these, an operation may be determined upon.

As to the gravity of resection, it has been by some surgeons over-estimated, and by others, perhaps, not sufficiently appreciated. The condition brought about is not precisely that of compound fracture, since there is far less injury inflicted on the soft parts, and the previous pathological processes have estab-

¹ Heard, New York Journal of Medicine, Oct. 1839.

² Ununited Fractures successfully treated, with Remarks on the Operation. By Henry J. Bigelow, M.D., etc. Boston, 1867.

³ Northwestern Med. and Surg. Journal, Aug. 1848.

⁴ Richmond and Louisville Med. Journal, Oct. 1874, and N. Y. Med. Journal, May, 1876.

⁵ Am. Journal of the Med. Sciences, July, 1866.

⁶ Ibid., July, 1859, and April, 1860.

⁷ Ibid., July, 1875.

⁸ British Med. Journal, Jan. 9, 1875.

⁹ Lancet, July 22, 1882.

¹⁰ Am. Journal of the Med. Sciences, April, 1879.

¹¹ Op. cit., p. 82.

¹² Malgaigne, op. cit., t. i. p. 315. Translation, p. 255.

¹³ Med. Times and Gazette, April 24, 1875.

lished a certain tolerance in the tissues which does not exist in a healthy limb suddenly subjected to violence. Moreover, the surgeon should be on his guard against all the avoidable sources of trouble, and may, before operating, assure himself that the patient is in such a state as to reduce the chances of failure to a minimum. On the other hand, however, there are risks which must be run; and the question is always to be carefully considered, whether the object to be gained is sufficient to justify taking them.

For the condition of some limbs affected with pseudarthrosis is by no means intolerable. Many a man is able to earn his living in spite of such a drawback, especially if it is the upper extremity which is affected. Even without any prothetic apparatus, such a thing may be. Thus Dr. Sutton¹ reported the case of a man who was shot in the arm, the ball passing through the humerus just above the condyles. It would appear that no very strict treatment was pursued. After some weeks, he regularly bent his arm every day. This arm got well with the elbow stiff, and a false joint at the place of fracture. The artificial joint supplied the place both of the elbow-joint and of the rotary motion of the forearm, in a very perfect manner; and the man was able to do a good day's work at any kind of labor. Norris² quotes a number of analogous cases.

It must further be remarked that the surgeon must be cautious in his promises to the patient as to the amount of benefit to be derived from operation. Although, as a general rule, the union of the broken bone may be expected, there may be a failure; and even if the main object be accomplished, there may be drawbacks to the ultimate result, which will cause much disappointment to the patient if his hopes have been raised too high. In illustration of this I may mention a case which came under my notice some years ago:—

R. G., aged 36, sustained a fracture of the right femur in December, 1865, in Nevada, and was kept in bed six weeks, with a screw extension apparatus. No union taking place, a seton was passed June 10, 1866; this failing, a steel screw was introduced November 3, and kept in for seven weeks. Abscesses formed on either side of the patella during that time, but the bone became firm. When I saw him several years afterwards, he had three inches shortening, the lower fragment being behind the upper. Only slight flexion of the knee was possible. He could walk very well, and all day, but not fast.

Had this patient been assured, after the manner of some over-sanguine surgeons, that he would be able to walk as well as ever, he would have had just cause of complaint, although the ultimate result was perhaps the best that could have been obtained.

Amputation has been resorted to in some cases of pseudarthrosis. It is of course only justifiable when the limb, after a thorough trial of all reasonable means, not only fails to unite, but remains in such a condition as to be a burden to the patient. Thus when the bone affected is in the lower extremity, and the fragments very loosely connected, the usefulness of the limb as a means of support and progression is lost, and the patient may be disabled from obtaining a livelihood. Or if there be extensive necrosis, or absorption of a very large portion of the bone, so that the member hangs dangling like a flail, it may be a mere incumbrance.

Persons in good pecuniary circumstances may often be enabled by means of prothetic apparatus to obtain a fair degree of use of a limb which would otherwise be only in the way; and even among the poor this should be suggested as a possibility. For example, if the humerus be the bone concerned, an appliance for its external support may, even if rude and homely, give the

¹ Western Journal of Med. and Surgery, Oct. 1842.

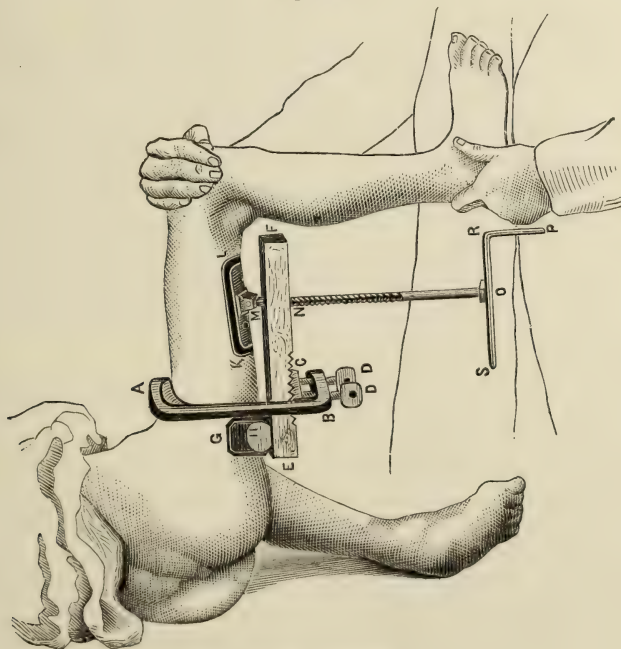
² Op. cit., p. 56.

patient such use of the forearm and hand as would be far better than any artificial substitute.

In any case it is a good rule for the surgeon to wait until the patient asks for the removal of the limb; and to satisfy himself, before consenting to a resort to this extreme measure, that there is no available method of restoring some degree at least of the usefulness of the part.

TREATMENT OF UNION WITH DEFORMITY.—If from restlessness or insubordination on the part of the patient, a fracture is found to be uniting in bad position, no time should be lost in correcting the deformity, and in so modifying the dressings as to make a more efficient retention of the fragments. The means of doing this must vary with the part concerned, and with the circumstances under which the treatment is conducted. Occasionally, the end may be gained by gradual pressure with properly padded splints; but, generally speaking, it is the better plan to bring the bone into good shape at once, the patient being etherized if necessary; and this may often be done with the surgeon's hands applied at either end of the bone, while his knee is used as a fulcrum. Should the union be already too firm for such force to be effective, the bone may be straightened over the padded edge of a table, with the aid of assistants. Or an "*osteoclast*," such as that represented in Fig. 813, devised by Dr. C. F. Taylor, of New York, may be employed. In

Fig. 813.



Taylor's osteoclast.

whatever way the thing be done, care should be taken to exert the force exactly on the spot desired, and to get as much leverage on the bone as possible; otherwise greater pressure will be necessary, or a second fracture may be produced at some other portion of the bone. The soft parts should always be well protected, and pressure upon large vessels or nerves should be studiously avoided.

For retaining the fragments in their improved position, a very rigid splint,
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properly shaped and padded, may be put along either side of the limb, and accurately bandaged. Firm compresses may be put under the padding, between it and the splint, at any points where special pressure is desired; and if extension seem to be needed, it may be made by an adaptation of methods to be hereafter described.

When consolidation has actually taken place, and the bone is permanently fixed in its distorted condition, there are several courses open to the surgeon. Brainard¹ advised weakening the bony texture at the seat of fracture, by *drilling* it subcutaneously, and then breaking it up in the manner already described. It must, however, be borne in mind that re-fracture is by no means a trifling affair. Union may fail to occur after it, whether it be accidental or produced intentionally by the surgeon; and symptoms of great gravity may ensue, as in a case reported by Hunt,² in which the patient, though he ultimately recovered with a useful limb, was placed in imminent danger of his life by the operation.

Resection of a wedge-shaped piece of bone from the projecting angle has been done in a large number of cases.³ It dates back as far as the sixteenth century, and from the published reports would seem to have been very generally successful. Yet there are not wanting accounts of its failure, and I have myself seen several instances in which it has proved fatal.

Subcutaneous osteotomy, either with the saw after the method of Adams, or with the chisel of Linhart and Maunder, is certainly a safer procedure; but for obvious reasons it would sometimes afford much less advantage in the correction of the deformity.

The deformities which are most frequently met with after fracture, are such as admit of no treatment. They are apt to be very close indeed to joints; I have seen them in the neighborhood of the elbow and ankle more often than elsewhere. They are mainly due to the extreme smallness of one fragment, which gives no purchase for any form of retentive apparatus; moreover, in these cases there is commonly very great swelling in the early, and even in the later stages, so that the precise condition of affairs cannot be determined until all chance of correcting it is past. Hence the surgeon, when called upon to attend fractures in these regions, should be careful to guard the patient or his friends from disappointment, and himself from blame, by stating from the outset the probability of more or less deformity and loss of movement resulting.

The foregoing remarks apply especially to the treatment of cases of angular deformity, which, indeed, is the one most generally brought to the notice of the surgeon, and the one which affords most chance of relief by operative measures. Mere shortening, after union has taken place, can scarcely be remedied, as it is due either to the loss of bone-substance or to overlapping of the fragments; and the section of a bone so united, in order to splice it anew, would be a procedure so grave in its risks as to prevent any prudent surgeon from attempting it. As to rotary displacement, disabling and disfiguring as it is, in the very rare cases in which it occurs, the prospect of improvement from an operation must be acknowledged to be too small to warrant its employment.

The subject is in practice still further narrowed by the fact that the cases which have been hitherto reported as dealt with by operation have nearly all, if not all, concerned either the leg or the thigh. Here angular deformity involves shortening of the whole limb, as well as a most awkward and incon-

¹ Chicago Med. Journal, Jan. 1859.

² Philadelphia Medical Times, Oct. 26, 1872; Surgery in the Pennsylvania Hospital, p. 151.

³ Norris, op. cit., pp. 124 *et seq.*

venient hampering of its movements, not remediable, as mere shortening is, by the wearing of a boot with a thick cork sole, or with a metallic stirrup to make up the want of length; and for such a condition the surgeon is justified in adopting severer measures, and running greater risks, than for one less distressing.

One or two instances are upon record in which surgeons have shortened a sound limb in order to obviate the limp due to a badly healed fracture in the other. I mention the fact only to enter a protest against any such procedure, which, in my opinion, could never be otherwise than rash and unsurgical, and the result of which could not be satisfactory.

Reference will be again made to the subject of union with deformity in connection with certain special fractures.

FRACTURES OF SPECIAL BONES.

FRACTURES OF THE BONES OF THE FACE.

From the size, shape, and arrangement of the bones constituting the skeleton of the face, they are, with the exception of the lower jaw, unapt to be broken singly. By crushing forces, such as a fall from a height on the face, the kick of a horse, or the passage of a wheel, very extensive injury may be inflicted. These fractures are generally compound, and often comminuted.

Cotting has reported¹ the case of a man run over by a cart, who had "a fracture of the lower jaw on one side, and a dislocation on the other; and a separation of the whole face from the base of the skull. The patient recovered without much deformity."

A man was brought to the Pennsylvania Hospital in 1855, who had had his head caught between the platform of a steam hoisting-machine and a floor. The face was separated—bones, soft parts and all—from the cranium, as far back as the sphenoid; a ghastly gash across the face, with a curious falling away of all the features from the forehead, had been produced, and the shock was so great that death ensued in a few hours.

A very remarkable case of smashing of the facial bones, not fatal, may be found recorded by Heath.²

Such very severe injuries are rarely met with; and the cases vary so much that they can only be discussed in the most general terms. Although at first sight they may be frightful, and it may seem as if recovery, if possible at all, would be necessarily attended with hideous deformity, the surgeon should not despair. He should endeavor to ascertain the exact extent and character of the fractures, and to replace the broken portions of all the bones involved. It may tax his ingenuity to keep them in place, but by careful adaptation of the means to be presently described, a great deal may be done. Union takes place very rapidly, and the disfigurement ultimately resulting is often far less than might at first be expected.

One rule is recognized by all the authorities in regard to compound comminuted fractures of the facial bones; it is, that splinters of bone should not be removed until they are actually necrosed and thrown off. Loss of substance produces the worst deformity; and it often happens that small frag-

¹ American Journal of the Medical Sciences, Jan. 1850.

² Diseases and Injuries of the Jaws, p. 55. London, 1868.

ments which seem hopelessly detached will adhere and live, perhaps helping materially to preserve the contour of the face.

Generally the attention of the surgeon is confined to the prevention of deformity after these injuries; but sometimes other bad consequences may ensue. Thus, Martin reports¹ a case in which amaurosis followed a fracture of the nasal portion of the superior maxilla, as well as of the palate bone, and most probably of the lachrymal; the patient, a man aged sixty, had been struck with a stone. Sight was ultimately restored.

A number of instances are on record in which foreign bodies have been forcibly thrust into the orbit, producing fracture of its bony walls, and injuring the eye, or even the brain itself; but these will be more appropriately discussed elsewhere.

The *treatment* of fractures of the facial bones must be directed to the replacement, as already said, of the fragments. This may often be done (after the careful removal of all foreign bodies, if the fracture be compound) by simply moulding with the fingers. Compresses should then be applied, exactly adapted to the size of the part over which pressure is to be made, and fastened in place by means of strips of fine isinglass plaster, or of rubber adhesive plaster. Of course the eyebrows, moustache, or any hair that may interfere with the dressing, should be carefully shaved. A light ice-bag, not filled so full as to prevent its taking the shape of the part, should be laid on, to keep down inflammation; the patient should be placed in bed; and liquid diet only should be allowed. If the effort of swallowing even this be productive of pain, or disturb the fracture, nutritive enemata may be employed.

It is rarely necessary to confine the lower jaw; but this may readily be done in case of need by means of a broad strip of rubber plaster applied under the shaven chin, and brought up with the ends crossed above the forehead.

When the fracture involves the alveolar margin of the upper maxilla, it may become necessary to have a cast taken of the teeth, and on this a vulcanized rubber mould, to serve as a splint. (In large cities it is generally easier to have this done by a dentist, to whom the process is thoroughly familiar.) Having put the splint in place, the surgeon brings up the lower jaw against it, and applies the broad strip of plaster above mentioned. A roller may be employed, in the form known as "Barton's bandage,"² if there be any objection to shaving the chin, or, in the case of females, to shaving the "front hair."

FRACTURES OF THE ZYGOMA.—Fractures of the *zygomatic arch* are very rare, and can only be caused by great violence. Malgaigne quotes from Duverney an account of "a young child, who, having in his mouth the end of a lace-bobbin, fell headforemost, so that the end of the bobbin, piercing the soft parts, broke the zygomatic apophysis from within outwards;" and another, in which Duverney says that he detected the fracture by passing his finger through the patient's mouth. But since, as Malgaigne justly remarks, the zygomatic arch cannot be reached in this way, there is good reason to doubt both these stories.

I have seen one case of fracture of the zygomatic arch, firmly united with deformity outward. It had occurred several months previously, by the falling of some chains on the head and left shoulder of the man, who was a sailor.

When the deformity is outward, which may perhaps result from the jamming backward of the malar bone, simple pressure inward may, in a recent case, overcome it. When it is inward, resort may be had to incision, and the

¹ Medical Press and Circular, Sept. 23, 1874.

² See Vol. I. p. 499.

introduction of an instrument to pry the fragments up. Malgaigne quotes a case thus operated upon by Ferrier, with a good result.

Muhlenberg¹ has recorded a case of fracture of the zygomatic process by the kick of a horse, followed by very troublesome false ankylosis of the temporo-maxillary joint.

MALAR BONE.—Fractures of the *malar* bone are exceedingly rare, as might be expected from its great strength, and from its attachments. A few instances are on record in which it has been separated from the adjoining bones, by very great force. In one, recorded by Malgaigne, there was depression, especially marked posteriorly, where the malar bone had been driven inward away from the zygomatic process of the temporal, and injury was done to the infra-orbital nerve, paralyzing the area supplied by it.

Replacement may be difficult, or even impossible; but the resulting deformity is not very great, unless from some such lesion of nerves as that just mentioned. There would be no valid objection to making a slight incision so as to introduce an elevator for the purpose of prying the bone up, as in Ferrier's case of depression of the zygomatic arch. In any such case, by making the section of the skin obliquely, the resulting scar would be materially lessened.

UPPER JAW.—Fracture of one *upper maxillary* bone is very rare, except in the alveolar portion. This is sometimes broken off by blows or falls; thus I have seen a semicircular piece detached in front, carrying with it the incisor teeth, in a man, who, having fallen from a wagon on his face, had a heavy box come down on his head as he lay; his lower jaw was also broken in two places. I have seen a much smaller piece knocked loose in a boy of six, by a fall against a step; he bled profusely for a time, but a good result ensued.

Occasionally the wall of the antrum is pierced by a thrust with a stick or sharp instrument; and in such a case the bone may be more or less splintered in various directions.

In most cases, the force fracturing the upper jaw-bone is exerted at the same time upon adjacent bones, and a more complex injury is produced. Thus the kick of a horse may crush and drive back both upper maxillæ, with the palate bones and vomer; or the same effect may be produced by a fall on the face from a height.

Wiseman² relates a curious instance, in which, a boy, aged 8, having had a kick from a horse, which drove the bones backward, he "caused an instrument to be made, whereby the great fractured body was more easily brought into its natural place, and also kept there by the hand of the child, his mother and my servants helping him some while." The result is said to have been "better than could have been hoped for from such a distortion in that place."

Hayes³ reports the case of a man, who, being thrown from a carriage and striking upon the end of a fence-rail, sustained compound comminuted fractures of the right upper maxilla and right malar bone, with simple fractures of the left upper maxilla and the lower maxilla on the right side. There was a good deal of cerebral commotion, and very severe hemorrhage; but the patient ultimately did well.

A man, aged 40, was brought to the Episcopal Hospital, in December, 1876, having been injured by the caving in of a culvert. He had a compound fracture of both nasal bones, the greater part of the left one being crushed off; and a laceration of the right lower eyelid, the ball being partially torn away and falling forward in the orbit. The whole face was enormously swollen, and there was continuous and free bleeding from the

¹ Phila. Med. Times, May 15, 1871.

³ South. Med. Record, 1882, p. 281.

² Op. cit., vol. ii. p. 253.

nose. On the next day, the swelling having subsided, a fracture was discovered beginning near the zygomatic arch on the right side, and extending across the upper jaw to the left side in front of the molar teeth. The fractured portion was very freely movable. Plugging of the posterior nares was resorted to, but the patient persisted in pulling the tampons away, and the hemorrhage was finally arrested by means of astringent injections. About the fourteenth day an abscess formed below the right eye, although the swelling and ecchymosis had almost wholly disappeared; this continued to discharge for some weeks, but no dead bone could at any time be felt. Union of the fracture took place readily, and on January 1, when I gave up the wards to Dr. John Ashhurst, Jr., there only remained a condition of ptosis due to tearing of the muscles above the right eyeball. This was remedied by Dr. Ashhurst by operation, January 11, and on the 20th the man went out cured.

Occasionally these injuries are productive of most ghastly deformity. Thus Malgaigne mentions a case seen by him a long time after the injury, which the patient had sustained, when a child, by the kick of a horse, comminuting the nasal, upper maxillary, and palate bones, and tearing and bruising the soft parts.

The nasal bones were destroyed; the anterior portion of the alveolar arch, and most, if not all, of the vault of the palate, had likewise disappeared. He had no nose nor mouth; the two lips being fastened together by a thick and firm cicatrix, the chin was continued up to an oval opening, formed between the two ascending processes of the maxillary bones as high as the frontal. By this one opening the patient breathed, spoke, ate and drank; when a piece of bread was put into it, the tongue was seen to come up, and to carry it down to the molar teeth, which performed their functions very well.

Concerning the symptoms and diagnosis of these cases, there is very little to be said; the nature of the injury is generally clear enough.

As to the *treatment*, the indications are to restore the fragments to their place as nearly as this can be done, and to keep them so until union, which generally takes place very readily, has occurred. In compound fractures, no splinters should be removed by the surgeon; they may unite, and if they do not, they will be thrown off. By the older surgeons, very complex appliances were devised, with head-bands, curved steel bars, and plates to press against the fragments. But the improved resources of modern dentistry render such apparatus, for the most part, needless; and in the great majority of cases the retention of the fragments can be effected by means of well-fitted vulcanite splints made to fit the dental arches. When these are arranged, a bandage is put on so as to restrain the movements of the jaws.

In some cases, after the first day or two, there is no difficulty in the administration of liquid food by the mouth, the patient learning to take it without deranging the fragments or the apparatus. But should there be any awkwardness in this, rectal alimentation may be resorted to.

FRACTURES OF THE NASAL BONES.—The bones of the nose are so thick, at their upper part, and so well supported, that they are not often broken except in their lower portions. Sometimes the septum suffers also; perhaps this is more generally the case than is suspected. It is not always easy to tell how far the injury consists also in separation of the cartilages from the edges of the bones; but this certainly does occur in some instances. The mucous membrane is often ruptured, and thus the fracture is rendered compound.

I have seen the nose broken by a cricket-ball, by a blow with the fist, by a blow received in boxing with the gloves, by a fall from a horse; the violence is always great and direct. Oftentimes it falls a little to one side or the other, so as to drive the nose crooked; and if this deformity is not corrected, it is very disfiguring.

Concussion of the brain is sometimes produced by the severity of the blow, but it seems very unlikely that the force can be transmitted through the nasal bones; it is more probable that it bears also upon the neighboring portions of the walls of the cranium.

Hamilton gives several cases of injury of the nose in children, in which the nasal processes of the upper maxillary bones were spread outwards; one of these was in a child only three weeks old, upon whose face a block of wood fell as she lay asleep. Such an occurrence could hardly take place in an adult.

The history of the injury, and the deformity, generally point to the diagnosis, which is nearly always rendered certain by the detection of crepitus. Other symptoms apt to be present are: severe pain and headache, hemorrhage from one or both nostrils, and sometimes emphysema in the surrounding areolar tissue. Swelling takes place so rapidly as often not only to make the exact seat and direction of the fracture obscure, but to interfere seriously with attempts to correct the displacement.

In many of these cases, especially if the violence inflicted has been very great, the bones are comminuted; and this adds notably to the difficulty of exact diagnosis as well as of treatment. The mere detection is easier, as well as the reduction, but the latter is hard to maintain.

Treatment.—Fractures of the nasal bones usually unite very readily, and this fact makes it very desirable that the displacement should be carefully corrected at the earliest possible moment. Hence the surgeon should at once press the fragments into their proper relation by means of an inflexible probe or director passed into the nostril, first on the one side and then on the other, moulding them at the same time with the fingers of his other hand applied on the outside. Another good plan is to use a pair of forceps. In many cases this will be sufficient; the deformity, once reduced, does not recur, and all that is needful is to keep down inflammation. Hemorrhage may be arrested by gently introducing a slender bit of ice, or by making the patient snuff up into the nose, water as hot as he can bear. Emphysema will subside of itself.

Should the fragments be so loose as to fall out of place, the attempt may be made to support them from within by means of pieces of thick soft-rubber catheters, with adhesive plaster externally; or the plan suggested by Dr. L. D. Mason¹ may be adopted. This consists in pushing through the base of the nose a strong pin (gilt or nickel-plated), and bringing a strip of rubber or adhesive plaster across from one end to the other so as to support and compress the parts.

For the treatment of *deflections of the septum* it is impossible to give any rules which shall apply to the more difficult cases, since they may require judicious modifications of operative procedures. Usually, in the simpler cases, properly applied pressure will suffice to overcome them.

Sometimes, when the nasal process of the upper maxillary bone is involved, there may be violence inflicted on the lachrymal duct. From this may arise stoppage of the duct and *fistula lachrymalis*; it is obvious that such a case would present unusual difficulties.

Malgaigne quotes from Duverney a case in which the ultimate result of an injury of this kind was a cancer, which destroyed the patient's life.

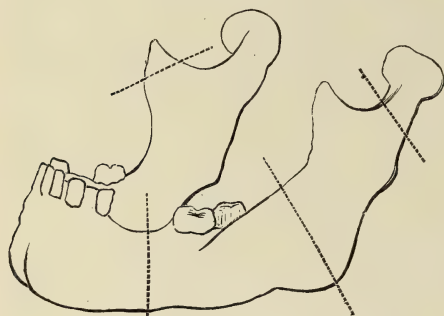
FRACTURES OF THE LOWER JAW.—The lower jaw presents the figure of a more or less pointed arch, bent upward near each buttress. Its body, comprising all in front of the angles, is thick and strong, and especially dense at

¹ Annals of Anatomy and Surgery. Brooklyn, 1880.

the symphysis. The rami are flat and comparatively thin, widening out transversely above and posteriorly to form the condyles, while above and anteriorly they run up into the thin points known as the coronoid processes. Without a careful study of the anatomy thus briefly sketched, a proper comprehension of the fractures of this bone is impossible; and such study must embrace the relations of the condyles to the base of the skull, as well as of the arrangements of the osseous structure as seen in sections. As to the latter, it affords a very striking illustration of the law before stated, that the lamellæ always run perpendicularly to the planes of pressure, and as nearly as possible parallel with the lines of muscular action. If a line be drawn from the symphysis to the centre of either condyle, it will be found to represent the resultant of all the normal forces to which the corresponding half of the bone is subjected.

As might be inferred from its complicated shape, the fractures of this bone present great varieties. They may result from direct violence at almost any point, or from indirect violence at one or even at a number of points. A force from without may tend to crush down the whole arch, in which case it

Fig. 814.



Fractures of the lower jaw.

may give way at its apex, at two or more weak points, or, if the force be exerted somewhat obliquely, at some point on the opposite side of the arch. Occasionally there is a distinct leverage, and sometimes a pressure on one side of the arch, with a counterpressure on the other.

The annexed diagram (Fig. 814) will serve to show the portions of the bone at which fractures are most apt to occur. The body is the part oftenest involved; it may be broken just at the symphysis (although on the authority of Boyer this was long thought to be impossible), or at a variable

distance from it. Double fractures, the body being broken through at two points, are by no means rare. The angle may give way, probably always to leverage across it. Occasionally the neck of the condyle has been broken, and very rarely the coronoid process.

Fractures of the lower jaw are rarely met with in children, by reason of the small size of the bone at their age;¹ and they are infrequent also in women and old people, whose habits of life exempt them in great measure from the kind and degree of violence by which these injuries are produced. Blows of all kinds—with the fist, with weapons, by the kicks of horses, by flying masses in mining accidents—falls on the face, and crushing forces, such as the passage of a wagon-wheel, are the chief causes of fractures of the lower jaw. Hamilton states that he has seen the bone broken on both sides by the violent grasp of a hand. Gross² mentions the case of a man of 70, who sustained a fracture of the neck of the bone during a violent paroxysm of coughing; this case I believe to be unique.

The amount of injury done to the bone varies greatly. No other single bone is so apt to be broken in several places; a fact which is readily explained by its complex shape, and its double articulation, giving two points

¹ Bouchut (op. cit. p. 759), says that fractures of the lower jaw are sometimes caused by the accoucheur in aiding delivery; but he cites no cases in proof of the statement. Two are quoted, however, by Gurlt (op. cit., Bd. ii. S. 409).

² Op. cit., vol. i. p. 940.

of resistance. Malgaigne quotes from Houzelot a case in which, the patient having been killed by a fall from a height, it was found that he had sustained fractures of the symphysis, of the neck of each condyle, and of both coronoid processes. Sir W. Fergusson¹ mentions an almost similar case, in which, however, only one coronoid process was broken. Heath² describes a specimen in the Museum of King's College, in which the body of the bone is fractured on either side, with the necks of both condyles. The probability is that in all these cases the force was received on the symphysis, and that the fractures were produced simultaneously, the bone yielding at all its weakest points.

Another specimen mentioned by Heath will serve to illustrate multiple fracture, due, it may be supposed, to lateral compression:—

“One fracture runs obliquely forward in front of the first molar tooth into the mental foramen. A second fracture runs vertically between the right incisor teeth. A third fracture runs very obliquely from the last molar on the right side down to the lower border of the bone opposite the canine tooth. This is met by a fourth fracture running obliquely backward in front of the first molar tooth of the same side. The lower border of the bone in the mental region is broken off and comminuted into numerous fragments, one of which contains the mental foramen of the right side. The left condyle is also broken off obliquely.”

Still another is described by Heath as follows:—

“A fracture extends obliquely backward between the second and third molar teeth of the *left* side, the external and internal plates of the bone being equally involved. There is also an oblique (downward and backward) fracture of the neck of the *right* condyle.”

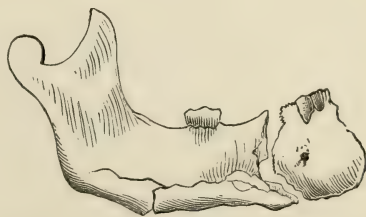
Fractures of the *body of the jaw-bone* are almost always compound, by laceration or rupture of the mucous membrane and underlying tissues, so that the air within the mouth gets access to the broken ends. Hence there is very apt to be suppurative, and the breath and secretions of the mouth are generally offensive from the decomposition which ensues.

The annexed sketch (Fig. 815) from a specimen in the Mütter Museum of the Philadelphia College of Physicians, shows a comminuted fracture, one portion of which, extending backward, is a mere fissure. Malgaigne quotes from Gariel an instance in which he “proved by an autopsy the existence of a fissure on a level with the dental canal, involving but part of the thickness of the bone;” the patient had fallen from a height.

When there is double fracture of the body of the jaw, the two lines of separation may be on the same side, or on opposite sides, of the symphysis. In the former case the intermediate fragment will not be as greatly displaced, or as hard to control, as in the latter.

Peirson³ has recorded an instance of double fracture of the jaw by the passage of a wagon-wheel, in which the middle fragment of bone, with the tongue, “was forced down the throat, so as nearly to occasion suffocation. The accident occurred in the night, but fortunately near a house whose inhabitants were awake; and the patient obtained the loan of an iron spoon, with which he contrived to drag the tongue forward, and prevent the impending suffocation, till I was enabled to secure the fragments

Fig. 815.



Comminuted and fissured fracture of lower jaw.

¹ System of Practical Surgery, p. 457. London, 1870.

² Op. cit., p. 5.

³ Remarks on Fractures. Boston, 1840.

by wiring the teeth. Great swelling followed, preventing deglutition for many days; but the patient, being supported through an œsophagus tube, eventually recovered."

Here it was the unopposed action of the muscles of the floor of the mouth that dragged back the fragment. Indeed, the effect of muscular action in causing or keeping up displacement is generally as clearly demonstrable in fractures of the lower jaw as in those of any other bone. In one case, in 1877, I was obliged to divide the muscles behind the symphysis, in a fracture close to that point, in order to reduce the fragment drawn back by them.

Occasionally, however, the degree of displacement is curiously slight, perhaps because the actions of different muscles counterbalance one another, as is noticed in some other parts of the skeleton also.

The signs of fracture of the body of the lower jaw are seldom very obscure, and sometimes very plain. Usually there is rapid swelling, which, when the bone is broken at one side, produces a curious twist of the face. Of course the motion of the part is limited, not only by the mere loss of continuity in the bone, but by the pain caused by it; and there is apt besides to be at least a temporary paralysis of the lip, from the injury to the inferior dental nerve. Hence speech is impaired and chewing often impossible. Profuse salivation is an almost constant symptom, and is made more apparent by the loss of control of the mouth. Sometimes, especially if the fracture be compound, the saliva is offensive, even to the patient himself. When the finger is inserted into the mouth, and the other hand applied outside, the line of the teeth is found to be abruptly irregular, and the fragments may be moved upon one another, with the production of pain, and of more or less distinct crepitus. It must be borne in mind that very few adults have perfectly regular teeth; and that even very marked irregularities do not indicate fracture, unless there is pain on pressure, and a corresponding deviation at some point on the opposite margin of the bone. Abnormal mobility, also, is very rarely wanting, though it may be so slight as to require extreme care for its detection.

The irregularity in the line of the teeth may be either transverse, one fragment being drawn down below the level of the other, or lateral, the anterior fragment generally slipping up within the posterior. This latter displacement is due partly to muscular action, but partly also to the fact noted by Malgaigne, that the plane of the fracture is apt to run inward and backward, the posterior fragment being beveled at the expense of its inner face; and this again, it seems to me, may be accounted for by the pointed arch-shape of the whole bone.

Although it would seem as if the dental nerve could never escape being torn or stretched in fractures of the body of the lower jaw, the occurrence of permanent trouble from this cause is very rare. Hamilton¹ gives one case, and refers to another seen by Désirabode.

Fractures at the *angle of the jaw* are generally oblique, in the direction shown in the annexed cut (Fig. 816), representing a specimen without history in the Mütter Museum. In this case there had been a false joint formed. Another case occurred in my ward at the Episcopal Hospital, in 1882, in the person of an elderly man who had fallen down, striking on a stone.

A much rarer form of fracture, partly involving the angle, is shown in Fig. 817; it represents a specimen also in the Mütter Museum, and of unknown history. Besides a very old and firmly united fracture, almost exactly at the symphysis, there is a recent oblique one beginning at the angle and running downward and forward to near the middle of the lower margin of the right half of the body of the bone.

¹ Op cit., p. 127.

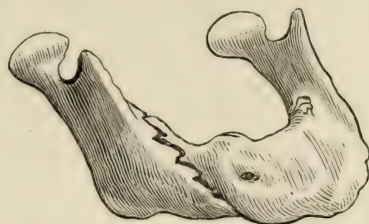
The *coronoid process* has very rarely been seen fractured; never without other lesions. Besides the cases before quoted from Houzelot and Fergusson, Gurlt gives one other, from Middeldorpf, and Tatum has reported¹ a fourth.

Fig. 816.



Fracture of lower jaw at angle.

Fig. 817.



Fracture of lower jaw at symphysis and angle.

A number of instances are on record in which the *condyloid process* has been broken, either by itself or, as in cases already referred to, along with other portions of the bone. I have seen the former condition caused by a stone, in a man injured by the premature explosion of a blast. Will² has reported one observed by him in a patient hurt by a falling wall. Watson³ has recorded a case of fracture of the necks of both condyles, by a fall from a yard-arm, the jaw-bone being otherwise uninjured. Cockburn⁴ gives a curious case in which by a blow on the *left* side of the face, the neck of the *right* condyle was broken. Other instances are quoted by Malgaigne, who points out that "the condyle itself remains in relation with the glenoid cavity; but the pterygoid muscle makes it execute a movement of rotation, carrying the fractured neck upward, forward, and inward, so that the fractured surface of the inferior fragment is in relation only with the posterior surface of the neck and of the condyle."

A case is reported⁵ in which, along with fracture about an inch to the right of the symphysis, there was discovered after death, fifty-four days from the time of the accident (a fall from a horse), a fracture "situated in the left condyle, and extending obliquely downward and inward." If this fracture involved the condyle itself, it was, as far as my knowledge goes, altogether unique.

The symptoms of fracture of the neck of the condyle may be readily inferred; they will be more clearly made out if the fracture is on one side only. Besides crepitus, pain, and inability to move the jaw, there will be a twisting of the chin toward the injured side, which, according to Malgaigne, is apt to be permanent in cases which do not prove fatal. This twist has an obvious diagnostic significance, as in unilateral luxation the chin is directed *away* from the injured side.

Fractures of the jaw vary greatly in their degree of gravity. Even when they are compound, healing often takes place with readiness, and in cases which look very unpromising a good result may be obtained by careful and well-directed treatment. Yet it must be remembered that injuries about the face are particularly liable to be followed by *erysipelas*; and the interference with nutrition which necessarily attends the lesion in question, may be a source of serious debility, especially in persons previously broken down by

¹ Lancet, Dec. 1, 1860; see also Trans. of Path. Society of London for 1861, p. 159.

² Lancet, Jan. 21, 1882.

³ New York Journal of Medicine, Oct. 1840.

⁴ British Medical Journal, December 28, 1867.

⁵ Medical and Surgical History of the War of the Rebellion, Part III., Surgical Vol., p. 649.

hard labor and bad habits. *Hemorrhage* very rarely ensues to a troublesome degree, unless in very bad compound fractures, in which the facial artery is wounded. Stephen Smith¹ reports a case in which, on the twentieth day after fracture of the body and ramus, the patient lost a pint of blood, probably from the inferior dental artery.

Necrosis of detached fragments, with loss of teeth, is a common consequence of severe fractures of the lower jaw. *Abscesses* often form, and may even prove fatal. Thus Mr. Abraham² exhibited to the Pathological Section of the Academy of Medicine in Ireland, a jaw fractured on the right side at the mental foramen, on the left side from behind the last molar tooth to the angle. The patient, a man aged 36, had been knocked down, and kicked while on the ground. "On the fourth day after the receipt of the injury he got out of bed, walked from his house a short distance, and returning fell dead at his own door. The fracture at the angle was found to be compound, communicating with the mouth; and an abscess traced from the parotid region down along the carotid artery into the pericardium, had formed in connection with it."

Richet,³ in 1865, called attention to the occasional occurrence of putrid infection (*septicæmia*) as the result of fractures of the jaw with laceration of the alveolar periosteum, and Chassaignac stated that he had seen and published similar cases.

Salivary fistula is said to have sometimes occurred after compound fracture.

Treatment.—This may be a very simple affair, or it may require great mechanical skill and ingenuity on the part of the surgeon. Sometimes reduction is readily effected, and maintained with ease by bandaging; sometimes, although the fragments can be replaced without difficulty, they resume their faulty relation the moment they are left to themselves. Sometimes the obstacles to reduction are very great.

One case is recorded by Lonsdale,⁴ in which a woman had the jaw fractured by a blow with a poker; "there was great difficulty in getting the two portions to lie in apposition, and the cause was not discovered till two or three days after the receipt of the injury, when, on passing a probe down, a tooth was felt jammed between the fractured surfaces; as soon as it was withdrawn, the ends of the bone came easily into contact." Sometimes splinters become wedged cross-wise between the fragments. I have already mentioned having had to divide the muscles just behind the symphysis in one case, in order to effect reduction; and my belief is that in very many cases, even with the best apparatus that can be devised, muscular contraction is not wholly overcome, but a certain degree—too slight it may be to produce obvious deformity—remains.

The great object to be aimed at is, so to restore the form of the bone that the teeth shall come into proper apposition with those of the upper jaw, and thus to insure to the patient the ability to masticate food. It is by no means always easy to judge of the degree of accuracy of the reduction, during the progress of the treatment; and the surgeon will do well as early as possible—say about the third week—to cautiously test the question by removing all apparatus, and, carefully supporting the broken bone below, bringing it up so that the line of the teeth, upper and lower, can be compared by means of the finger inserted into the mouth. Should there be any defect in the apposition, it may be much more readily corrected at this stage than at any later period.

¹ New York Journal of Medicine and Surgery, January, 1857.

² British Medical Journal, December 23, 1882.

³ Gaz. des Hôpitaux, 1865; Am. Journal of the Med. Sciences, July, 1866.

⁴ Practical Treatise on Fractures, p. 229.

In effecting reduction, the surgeon should pass one or two fingers of one hand into the patient's mouth, applying them to the teeth, while with the thumb and fingers of the other hand he endeavors to bring the bone itself, at its lower border, into proper shape. As a general rule, the greater the violence which has caused the injury, the more will the bone be likely to be shattered, and the soft parts to be torn.

Fractures at or close to the symphysis are more easily kept reduced than those of the middle of the body at either side. And fractures at the angle are but little liable to displacement, partly because they are at the widest part of the pointed arch before spoken of, partly because the disposition of the muscles is such that neither fragment is pulled upon more than the other; they are as it were balanced.

The bandage most frequently employed in Philadelphia, in the retention of fractures of the lower jaw, is that known as Barton's.¹ Hamilton describes an apparatus made with straps and buckles, on a very similar plan, which he has used with satisfaction. Before applying either, it is better, if the patient be a male adult, to have the face shaved, or, at least, to have the beard clipped very short; the hair, if long, should also be cut.

If the fracture is at either side, it will readily be seen that the pressure of the bandage may be so exerted as simply to flatten out the broken bone, as it were; an action which, carried to excess, would produce between the fragments an angle salient toward the mouth. Hence it is much better to use a splint made of binder's board, felt, or gutta-percha, moulded to fit the chin, and smoothly lined with a thin sheet of raw cotton, or with Canton flannel.

Greater security may be given to this apparatus, if, before applying the bandage, the outer splint be fastened in place by a strip of plaster about an inch and a half in width, passing well up on each cheek. What is known as "rubber adhesive plaster" is the best, but any well-made adhesive plaster, not too fresh, will answer. If the strip be made twice as wide, and doubled on itself so as to have an adhesive surface toward the splint and another toward the bandage, the latter will be still further prevented from slipping. Such a precaution is by no means needless in the cases of some very unruly or delirious patients.

When the surgeon has any doubt as to the accurate retention of the fragments, a very simple and easy expedient may be adopted to insure it, at least until a permanent apparatus can be made. A large vial-cork may be cut down so as to square it on two opposite sides, leaving it of sufficient thickness for spaces to be cut out on these square sides, on one side for the upper and on the other side for the lower teeth. This shaping can be easily done with a sharp knife, by any one with ordinary dexterity in such matters. When finished, this *interdental splint* can be fitted to the upper teeth, the lower jaw brought up to it, and the fragments properly placed in their groove, after which the outside splint and bandage may be put on.

Another very ancient device is that of surrounding the adjacent teeth on the two fragments with a wire, which thus includes them in a loop, secured by twisting the ends of the wire. Such a loop need not be retained very long, and, indeed, ought not to be, lest it should injure the gums; a week or ten days will generally be a sufficient time, as the process of union will then have begun, and the fragments will be apt to keep their place.

In cities, or wherever the services of a competent dentist can be had, the best plan is to have a mould taken of the patient's jaws, the fragments being held in place by the surgeon. From this an accurate cast may be made, and upon this again a vulcanite plate, to fit above and below. When skilfully

¹ See Vol. I. p. 500, Fig. 64.

done, this gives the surgeon as absolute control of the fragments as it is possible to obtain. By some, splints of this kind have been attached to steel arms or branches coming out at the corners of the mouth, and connected with an outside framework, a padded plate fitting underneath the chin; when such an apparatus is employed, there is no need of the upper teeth being taken into the account at all, as the fragments are securely held between the mould above and the padded plate below. The arms connecting the two are arranged with screws and nuts, so that they can be tightened to the requisite degree.

Rutenick, Lonsdale, Gunning, Bean, Kingsley, and many others, have exercised much ingenuity in devising modifications of apparatus based upon this idea. The appliances known by their names may be found described in detail in so many systematic works, that it seems hardly worth while to devote more space to them here.

During the confinement of the jaw by any of the means now mentioned, it is obvious that the patient is debarred from the use of ordinary food; and by some of the older writers it was advised that a front tooth should be drawn in order to allow of the introduction of milk, soups, etc. This, however, is unnecessary; scarcely any one has the teeth so closely set together as to prevent liquids from finding their way to the back of the mouth. If from swelling or other cause deglutition be very much hindered, nourishment may be administered either by means of a tube passed along the floor of the nose, and so down into the stomach, or by enema. The difficulty of swallowing rarely persists more than a few days.

Suturing of the fragments has been practised with advantage in a few instances of very oblique fracture, where retention by ordinary means was found impossible. Kinloch's case,¹ the first of which I have any knowledge, was one of compound fracture, and the result was excellent. Thomas² has reported two cases attended with like success.

Fastening the fragments together, by means of silver pins, as recommended by Wheelhouse,³ appears to offer no advantage over the ligature, while it multiplies the chance of irritation of the soft parts.

Fractures of the lower jaw are sometimes, but very rarely, complicated with luxation of one condyle. Probably the dislocation occurs first, as otherwise there would scarcely be purchase enough to force the condyle out of its socket. Details of the reported cases are given by Heath.⁴ In one case only were both condyles displaced, and the necks fractured; and in one, in which only one condyle was luxated, it was also broken off at the neck.⁵ Replacement of the condyle would, under such circumstances, be obviously impossible; but when the fracture is far enough from the condyle to give sufficient purchase, the luxation may be reduced in the ordinary manner, and the treatment of the fracture then proceeded with.

Non-union.—While, as a general rule, fractures of the lower jaw unite readily, there are not a few cases on record in which they have failed to do so. Malgaigne quotes from Bérard a curious case of “a child whose fracture made no progress toward recovery until the apparatus, an ordinary bandage, was removed.” On a previous page a specimen of false joint formed at the angle was depicted; and Physick's case, in which union was brought about by the employment of a seton, is among the most widely-known instances of success by that mode of treatment.

But little need be said as to the course to be adopted when union takes

¹ American Journal of the Medical Sciences, July, 1859.

² Lancet, August 17, 1867.

³ Ibid.

⁴ Op. cit., p. 22.

⁵ Both these cases are quoted from Bonn by Coote, in Holmes's System of Surgery, 2d ed. vol. ii. p. 429; Am. ed. vol. i. p. 680.

place slowly, or when a false joint has formed, in fractures of the lower jaw, since the general principles already laid down are of particularly easy application here.

In cases of slow consolidation, the surgeon should first have made a very accurately fitting interdental splint, and, after thoroughly rubbing the fragments together, he should apply it, so as to keep them at absolute rest in good relative position. Failing in this, he should proceed at once to drill the fragments, and wire them together, confining the jaw subsequently with a moulded outside splint and a carefully applied bandage.

When a false-joint has formed, the fragments may be at once scraped, drilled, and wired.

It will, perhaps, seem as if so prompt a resort to the most heroic measures, without a previous trial of milder means, were at variance with the accepted rules of surgery. But it must be remembered that this bone, though easily accessible, is very difficult of control; and that the interference with nutrition during the period required for such attempts, would be of itself a serious evil.

Union with Deformity.—When a fracture of the jaw has united with the fragments in bad relative position, it is very seldom that any means of correction are available; only, in fact, when the bone has been broken somewhere near the symphysis, as elsewhere interference would either endanger the vessel or nerve, or both, or would be useless by reason of the want of purchase for mechanical treatment. Yet it may be that in some few cases, even as far back as the angle, subcutaneous osteotomy might afford a chance of dividing the uniting medium, as it would indeed be the best means of doing it at any point. Afterward, drilling, wiring, and a well made interdental splint, with a bandage externally, should be employed.

FRACTURES OF THE LARYNGEAL APPARATUS.

FRACTURES OF THE HYOID BONE.—From its position and connections, this bone is greatly protected, yet a number of instances are upon record in which it has been broken, either alone or along with severe injuries of neighboring parts. It is of the former class of cases only that I have now to speak, since this lesion is in the others a comparatively unimportant complication.

Strange as it may seem, the hyoid bone is seldom fractured in cases of hanging, whether suicidal or judicial. Casper says¹ that he has never seen it in any of the numerous bodies officially examined by him. Mackmurdo, for many years surgeon to the Newgate Prison, in London, is quoted by Gibb² as stating that he had only once seen the body of the bone broken in a hanged man, and that in three or four only had he seen one or other cornu (never both) fractured. In suicides, the body of the bone was seen broken by Orfila, and a cornu by Dieffenbach and Cazauvieilh (two cases).

In the body of Wirz, hanged at Washington, D. C., in 1865, "the hyoid bone had received six injuries; separation of the greater and lesser processes on both sides from the body of the bone, and true fracture of the outer third of the greater process on either side."³

This bone has been several times observed to be broken by throttling (Auberge, Dieffenbach, Murchison, Lalesque, Devergie, Helwig), and by falls in which the front of the neck is struck against some resisting body (Harley,

¹ Forensic Medicine, vol. ii. p. 174.

² On Diseases of the Throat and Windpipe, etc. London, 1864.

³ Med. and Surg. Hist. of the War of the Rebellion, Part I., Surg. Vol., p. 400.

Gründer, T. Wood), and in three cases the lesion was ascribed to muscular contraction (Ollivier d' Angers, Obre,¹ La Roe²).

Ollivier's case was that of a woman, aged 56, who made a false step and fell, her head being thrown forcibly backward. "At the same moment she heard a very distinct crack at the upper part of the left side of the neck; there was a fracture of the greater cornu of the hyoid." La Roe's patient sustained the injury in yawning.

From the few recorded cases, the symptoms of this fracture would seem to be: sharp, sticking pain; sometimes spitting of blood; swelling, and embarrassment in speaking or swallowing; and, when the fragments remain in contact, crepitation. Upon examination with one finger in the mouth and one outside, the fragments can be felt, and perhaps pushed into place.

In Gründer's case, the only uncomplicated one which proved fatal, the broken cornu was found "jammed between the epiglottis and the rima glottidis." In all the other instances, there was union by means of callus; and this had taken place in two specimens, one without history,³ and the other taken from a woman who several years before her death had received a blow on the neck by a heavy boot falling on her as she lay asleep.⁴

As to the *treatment*, the first point must of course be to remedy any displacement of the fragments, by manipulation; next to allay inflammation, by suitable local applications; to enjoin upon the patient perfect quiet, and to provide for his due nourishment, should swallowing be difficult or impossible, by means of nutrient enemata. A stomach-tube has been used in some cases, but at some risk of disturbing the fracture.

FRACTURES OF THE LARYNGEAL CARTILAGES.—The laryngeal cartilages are from their situation exposed to the same causes of fracture as the hyoid bone—compression by hanging or throttling, falls, and blows—but they are less under the shelter of the lower jaw, and hence more frequently suffer.

Casper⁵ says that he has never yet seen fractures of the larynx in cases of hanging; but instances are recorded by Weiss and Cazauiellh, and in the Warren Anatomical Museum, in Boston, there is a specimen of fracture of the right upper cornu of the thyroid cartilage from a Sandwich Islander, who took his own life in this way. A case in which the cricoid was broken by hanging is also recorded by Porter.⁶ (In the official report⁷ of the autopsy on the assassin Guiteau, it is stated that the thyro-hyoid membrane was ruptured, and that the hyoid bone and thyroid cartilage were widely separated.) Morgagni⁸ says: "That the larynx is sometimes broken from that cause [hanging], I have seen, together with Valsalva." . . . "A hanged man had the sternothyroidei and hyo-thyroidei muscles torn, so that only a membranous substance remained in their place about the annular cartilage. And this very cartilage was also broken asunder." . . . "The celebrated Professor Weissius found, in a soldier who had been hanged, the annular cartilage broken asunder into many pieces, and the inferior part of the trachea entirely torn away from the larynx."

Malgaigne quotes cases of fracture of the thyroid cartilage, by the grasp of a hand, from Ladoz and Marjolin. Fractures of the cricoid cartilage alone, produced in the same way, have been reported by Fredet⁹ and Pemberton.¹⁰

¹ Gibb, op. cit.

² Gibb, Trans. of the Pathol. Society of London, 1862.

³ Gurlt, op. cit., Bd. i. S. 327.

⁴ Archives of Laryngology, June 30, 1880.

⁵ De Sedibus et Causis Morborum, Lib. ii. Epist. xix.

⁶ Brit. and For. Med.-Chir. Review, Jan. 1869.

⁷ Medical Record, April 15, 1882.

⁸ Op. cit.

⁹ Medical News, July 8, 1882.

¹⁰ Lancet, May 22, 1869. Mr. Pemberton refers also to papers on Manual Strangulation, by Wilson and Keiller, in the Edinburgh Med. Journal for 1855 and 1856.

Wales¹ reports a case of fracture of the thyroid cartilage and lower jaw by a fragment of a shell; Hamilton gives one case² of fracture of the thyroid and cricoid by a kick from a man, and another³ by the kick of a horse. I have myself met with a case⁴ of supposed fracture of the larynx (probably of the thyroid cartilage only) by the kick of a man.

Hunt records⁵ an instance in which both the thyroid and cricoid were broken by a blow from a piece of wood thrown off from a circular saw. Perhaps the most remarkable case, however, is that reported by Sawyer,⁶ in which there was double fracture of the lower jaw, with fracture of the hyoid bone, thyroid cartilage, right radius, and left patella; tracheotomy was performed on the fifth day, having become urgently necessary; the patient ultimately made a good recovery.

Instances have been reported by Maclean⁷ and Roe,⁸ in which the thyroid cartilage alone was broken by falls against resisting objects—a stump and the edge of a table. Sometimes the hyoid bone also suffers, as in a case recorded by Koch,⁹ and in Sawyer's case above referred to; and sometimes, again, the cricoid is involved, as in the instance quoted by Malgaigne from Plenck.

Fractures of the cricoid alone by hanging and throttling have already been spoken of; Stokes records¹⁰ an instance in which this lesion was the result of a kick.

The *mechanism* of production of these lesions is sufficiently apparent.¹¹ It does not seem that the rigidity of the cartilages has anything to do with their liability to fracture: Gibb¹² mentions a number of cases occurring in young children.

As to the *symptoms*, there is always more or less swelling of the parts, often increased by the occurrence of emphysema; in the case observed by me, there was a curious limitation of the emphysematous condition to the cervical region both anteriorly and posteriorly. Pain, increased by efforts at coughing or swallowing, is generally present, and is sometimes marked; there is always tenderness, and often the handling of the parts elicits crepitus. The voice is husky, perhaps almost extinct; breathing is difficult, and the face generally more or less livid, with an anxious expression. A very constant symptom is the expectoration of bloody, frothy mucus, with or without cough. From the presence of all or most of these phenomena, and the history of the case, a diagnosis may be arrived at without much difficulty.

The *prognosis* is a matter open to more doubt. In Plenck's case death was instantaneous, as it was also in a case of throttling reported by Damonetta;¹³ but more frequently the patient dies gradually by suffocation, from hemorrhage beneath the mucous membrane, inflammatory swelling, or œdema. Roe, in the article before quoted, speaks of fracture of the cricoid as "almost invariably" fatal; and from the records it would seem as if he might have

¹ Am. Journal of the Med. Sciences, Jan. 1867.

² Medical Record, Jan. 1, 1867.

³ Fractures and Dislocations, 6th ed. p. 153.

⁴ Reported in Archives of Laryngology, March, 1880.

⁵ Am. Journal of the Medical Sciences, April, 1866. The reader may consult with advantage the table of 29 cases given at the close of Dr. Hunt's article.

⁶ Ibid., Jan. 1856.

⁷ Canada Med. Journal, Sept. 1865.

⁸ Trans. of Am. Laryngological Association, 1880, p. 99.

⁹ Quoted by Roe, loc. cit.

¹⁰ Dublin Quarterly Journal of Medical Science, May, 1869.

¹¹ In the Index Medicus for 1882 (p. 380), there is given a reference to a paper by R. Haumeder, "Über den Entstehungs-mechanismus der Verletzungen des Kehlkopfes und des Zungenbeins beim Erhängen," in the Wiener med. Blatt, 1882, S. 810. This probably embodies the latest views on the subject.

¹² Diseases of the Throat and Windpipe, etc., p. 436.

¹³ Ann. des Mal. de l'Oreille et du Larynx, Mai, 1879.

omitted the qualification. One case only has been reported¹ in which recovery is claimed to have occurred after lesion of this part of the larynx; I have seen a French translation² of the account, which is too vague, and apparently too inaccurate, to weigh against the mass of testimony on the other side. (Possibly this gloomy condition of affairs might be changed by the very early performance of tracheotomy). Unfavorable indications are, in any case: great interference with breathing, severe cough, marked cyanosis, and free spitting of blood. When recovery takes place, the voice is apt to be permanently altered.

As to *treatment*, anodyne fomentations and poultices, the latter made of light materials, may be used locally, to allay irritation. No compresses, or other confining apparatus, should be employed, as they would only still further embarrass respiration. Opiates may be given by the mouth if swallowing is not very difficult. Absolute silence and rest in bed should be enjoined, and a warm and moist atmosphere should be provided by the usual means. For a few days, at least, the patient should be fed by enemata.

I think that the invariable rule should be to contemplate from the very first the probability that tracheotomy may become necessary, and to arrange for its immediate performance should the breathing become increasingly difficult. No case of this kind can be safely left unwatched; and unless, as in a well-ordered hospital, aid can be instantly rendered in case of need, it would be the best practice to open the trachea at once, in anticipation of trouble.

FRACTURES OF THE RIBS, COSTAL CARTILAGES, AND STERNUM.

For a reason already stated, fractures of the vertebræ are given consideration elsewhere; and the subject now to be taken up embraces the fractures of the lateral and anterior portions of the wall of the thorax. In order to a full understanding of these injuries, the anatomy should be carefully studied, not only of the separate bones, but of the framework as a whole, and as covered in great part by muscular and other structures.

It will be seen that the seven upper ribs are attached, not rigidly, but nearly so, both posteriorly and anteriorly; the next three have in front a greater degree of motion, by reason of the length of the cartilaginous branches which run up to give them an indirect connection with the sternum; while the eleventh and twelfth are merely tipped with cartilage. Each rib has an angle, a curve, and a twist; and the mobility of the walls of the chest is the aggregate of that of all the constituent ribs. The sternum has a mobility dependent chiefly on the elasticity of the ribs and their cartilages.

FRACTURES OF THE RIBS.—The ribs may be broken by direct or indirect violence, or by muscular action. They are, in children, extremely elastic, and are not often fractured in them except by very great crushing force. Holmes³ quotes the opinion of Coulon, that incomplete fractures of the ribs are very common in childhood. One case is mentioned by the latter author, in which a child, who died of rupture of the lung, was found to have sustained partial fracture of two or three ribs on each side. It is highly probable that in many cases in adults, supposed to be mere contusions, one or more ribs may have given way in a part only of their thickness. Mention has

¹ In the Index Medicus for Aug. 1882, the reference is given as follows: "Masucci (P.) Su di un caso di frattura della cricoide, seguito da guarigione. Arch. Ital. di Laringol., Napoli, 1881-2."

² In the Revue Mensuelle de Laryngologie, etc., 1 Nov. 1882.

³ Surgery, its Principles and Practice, p. 219, note.

already been made of two cases of "willow fracture" of the ribs from gunshot, noticed during the late war.

Direct violence may affect only a limited area, and one rib only may be broken; or it may crush a large portion of the chest-wall. *Indirect violence* generally acts in the latter way. Blows with the fist or with weapons, falls against resisting objects, etc., are the chief direct causes of fracture in this region. Of indirect causes, one of the most frequent is the passage of a wheel over the chest; the caving in of earth, crushing under heavy falling bodies, and the pressure of crowds, have also been noted. Double fractures are not unfrequent.

An important difference obtains between the effects of these two forms of violence. Direct force is apt to drive the broken ends inward, so that the inner wall of the bone or bones gives way first, and is more extensively splintered; and, hence, injury to the pleura or lung is more apt to ensue, either as a primary or secondary effect. By indirect violence, on the other hand, the arch of the thoracic wall is bowed outward, and the fragments are caused to project.

For an obvious reason, when the ribs are broken by direct force, the line of separation is apt to be less oblique than when the fracture is due to indirect violence.

Fractures of the ribs by forces acting from without, are much more common in men than in women, the habits and occupations of the former involving more exposure to such causes of injury.

Muscular action has been observed as a cause of fracture of the ribs in a large number of instances. It is not easy to understand the mechanism of such lesions, unless we suppose that they are the result of a sudden pull by the extra-thoracic muscles, as by the serratus magnus (its lower part), the shoulders being fixed. Coughing has been the action to which these accidents have been most frequently due; the portion of the chest involved has been near or below the middle, and, whether from coincidence or not, almost always the left side. Thus Després¹ has recorded the case of a woman, aged 53, who broke "the eleventh left rib, four fingers' breadths from its junction with the cartilage," in a fit of coughing. Doit² reported a fracture of the sixth left rib in its anterior third, produced in the same way, the patient being a man, aged 59. Malgaigne mentions a case observed at the Hôpital Necker, in which "there took place in less than one month three successive fractures, affecting first the tenth, then the ninth, and, lastly, the eleventh rib."

One case is related by Castella,³ in which a fracture of the ninth rib on the left side, was caused by sneezing. Gurlt quotes from Groninger a case in which the seventh and eighth ribs gave way in a robust man of 45, as he made a great effort to save himself from falling. Nancrede⁴ records the case of a robust Englishman, aged 44, who sustained a fracture of the second rib on the right side, in an effort to straighten a scythe-blade.

Fractures of the ribs are rarely either compound or comminuted; they are very generally complicated with pleurisy, although this may be of very limited extent.

The chief *symptoms* of fracture of a rib are pain and difficulty of breathing, which are combined so as to constitute what is known as "a stitch in the side." The respiration is apt to be largely abdominal; as a rule, the patient can lie indifferently on either side. Cough, slight and suppressed, but constant, and troublesome from the pain caused by it, is very generally present;

¹ Gazette des Hôpitaux, 28 Fév. 1882.

² Med. Times and Gazette, May 6, 1882, from L'Union Médicale, 29 Avril.

³ Ibid., Jan. 25, 1862, from Gaz. des Hôpitaux, 1861.

⁴ Philadelphia Med. Times, May 23, 1874.

it has been suggested that it may be reflex, from the irritation of the intercostal nerves, which can scarcely fail to exist. Crepitus may often be elicited by merely placing the hand flat on the seat of injury, or by making alternate pressure on either side of it; or by placing the ear over the spot, and inducing the patient to take as long a breath as he can. Tenderness on pressure is a constant symptom.

When the lung has been punctured by one of the fragments, emphysema is very generally the result, air escaping into the subcutaneous areolar tissue. Of this Hammick¹ gives a very curious instance:—

“A man was brought in for fractured ribs from the Glory, then lying in Cawsand Bay, and when the sailors uncovered him, it being night and very dark, they were astonished, for when they quitted the ship, immediately after he had fallen, he was a thin person, but from the escape of air into the cellular membrane, he was blown up to a frightful size—the scrotum being as large as his head—the breathing so laborious, and the symptoms so urgent that, without waiting to put him into bed, with a scalpel I freely incised several parts, particularly the scrotum; the escape of air was so great that it blew out a large candle held before it. By the next day there was only a little crackling feel in the neighborhood of the fractured ribs; he recovered finally from the injury, though it was many months before he could be discharged from the hospital.”

The slight pleurisy, already mentioned as generally attendant upon fractured rib, may spread and assume such proportions as to endanger life; and pneumonia may be superadded to it.

The *prognosis* is, of course, grave, if the injury is very extensive; yet Holmes² says he has seen a young woman recover from fracture of every rib in the body, and comminuted fracture of the left clavicle involving such damage to the brachial plexus as to cause permanent paralysis of the arm.

Injury to the vessels, or to the viscera, adds very greatly to the danger. Turner³ has recorded an instance in which a robust man, fencing with another in sport, was struck with a light cane over the eighth rib on the right side, and died from rupture of the intercostal artery, five pints of blood being found in the pleura.

Wounds of the heart are not infrequent. Lonsdale⁴ gives an account of a man, aged 21, run over by a wagon-wheel, in whom the following condition was found after death:—

“Eight ribs of the left side were fractured at their posterior part, about an inch from their tubercles; and the four middle ones were broken at the anterior part as well, causing a double fracture. The pericardium was filled with blood, and a large quantity had escaped into the chest as well. The left auricle was found to be torn by the fractured ends of the ribs having been thrust against it.”

Eve⁵ quotes from Lees a very singular case:—

“A brewer’s man had fallen under a dray, when it was heavily laden, which passed over his chest; he was lifted up and complained of pain and weakness, but was able to continue sitting on the side of the dray, driving the horse for nearly an hour, when being in the vicinity of the hospital he thought he might as well get himself examined; he walked in and lay on a bed, but on turning on his side he suddenly expired. On dissection it was found that the fifth rib was fractured, and that the extremity of one portion had penetrated the pericardium, but had freed itself from the heart; and this, as Mr. Wilkin observes, accounts for the sudden death of the man. For it is probable that the portion of rib had filled up the wound of the heart, and thus prevented any hemorrhage until his arrival at the hospital, when, on its coming out, the sudden effusion of blood into the pericardium caused death.”

¹ Op. cit., p. 163.

³ Med. Times and Gazette, Dec. 22, 1860.

⁵ Remarkable Cases in Surgery, p. 221.

² Op. cit., p. 218.

⁴ Op. cit., p. 258.

Hammick¹ mentions a case in which a man was struck on the side by the end of a flying rope, and died immediately:—

The post-mortem showed that “one rib only had been broken, both ends of which had been driven inward, piercing the very apex of the heart, penetrated both ventricles, and then had returned to their situation by their own elasticity; the pericardium was full of blood, but none had escaped into the chest.”

Hammick suggests that death was due here to the shock to the diaphragm or to the heart; but it seems as if the escape of blood into the pericardium might amply account for it.

Still another case may be cited, reported by West:²—

A young man fell into a coal-pit, and was taken out dead. There was no wound on the surface; but the sternum was broken into two fragments, and the third, fourth, fifth, sixth, and seventh ribs on the left side were fractured also. The pericardium and pleura were full of black fluid blood, and both right and left ventricles of the heart extensively lacerated.

Fractures of the ribs generally unite without difficulty, in the simpler cases; but from the unavoidable mobility of the parts there is apt to be some excess of callus. When several ribs are involved this condition is more marked, and sometimes—as in a specimen in the Wistar and Horner Museum of the University of Pennsylvania—there are curious stalactitic prolongations from each bone at the fractured part, as if the plasma had been pulled upon and drawn out when soft.

Non-union is sometimes met with:—

Boardman³ found in a colored girl, aged 22, a fracture of the eighth right rib, of three or four months' standing, ununited, and the fragments carious; a fistulous opening led into the pleura, which was coated with lymph and contained about two pints of pus. On the left side, the eighth rib was also broken, and there was an abscess between the intercostal muscle and the pleura, pointing within, and apparently ready to burst. This latter lesion was only discovered after death; the other was attributed to a kick.

The *treatment* of fractured ribs, when uncomplicated with lesions of the internal structures, consists simply in immobilizing the parts; and this is best done by means of adhesive strips, as first recommended by Hannay.⁴ It had been previously effected by the application of bandages, either ordinary wide rollers, or broad strips of flannel or muslin pinned about the chest. At the present day, the adhesive plaster is in very general use; it is cut into strips from eight to sixteen inches long, according to the size of the chest, and about an inch and a half in width. These are put on very firmly, parallel with the ribs, and overlapping one another from above downward, each one covering about one-third or one-quarter of the width of the preceding one. By Erichsen and others it is advised that the strips should surround the whole body; but this will be found to impede respiration and give trouble. It is better to let the strips extend no further than the median line in front and at the back. Before applying the plaster, any marked displacement of the fragments should be corrected by suitable pressure and manipulation, the patient being directed to fill the chest as much as possible during these attempts. My own practice is to apply the strips during expiration; and the pain caused by the act of breathing ought to be markedly relieved. When the fragments project outward, a compress of lint, not too thick, may be placed over the angle before the plaster is put on. When they are driven

¹ Op. cit., p. 165.

² St. Thomas's Hospital Reports, N. S., vol. i. 1870.

³ Proceedings of the Pathological Society of Philadelphia, vol. ii. p. 130.

⁴ London Medical Gazette, November, 1845.

inward, two compresses may be employed, at such points as to tilt up the ends and take off the pressure upon the parts within. Operative interference for the purpose of prying up a fragment by means of the finger, a lever, or a blunt hook, inserted through an incision of the skin, has been suggested. Malgaigne mentions "removal of a piece of rib" as having been resorted to by Soranus and by Rossi; but these, I believe, are the only known cases of the kind. He proposes the use of a hook curved like a tenaculum, inserted over the upper border of the bone; and if the hook were blunt this could readily be done without wounding the pleura. Such a procedure could, however, very rarely be called for.

Should the fracture involve several ribs, I believe advantage would be gained by the use of a short, thin slip of wood, properly covered, and applied across the posterior portions of the ribs, so as to act as a splint as well as a compress, pushing the fragments outward, away from the pleura and lung. It might of course be held in place by adhesive plaster, put on in the manner above directed.

When a bandage is used, it is best made of flannel, about three inches wide; if cut obliquely, or "bias," it will be much more elastic than if torn lengthwise of the piece. One or two turns round the shoulders will prevent it slipping downward, and a few strips of adhesive plaster across it on either side (not in front), running down as far as the pelvis, will keep it from slipping upward.

Emphysema generally disappears of itself, without treatment. As to complications from intra-thoracic inflammation, they must be dealt with on the principles laid down in works on the practice of medicine. I may, however, say that leeches, applied just at the seat of injury, or cups in its immediate neighborhood, have sometimes seemed to me to be of great service. General bleeding I have never had occasion to employ in cases of this kind.

Internal hemorrhage, in the recorded cases, has usually been speedily fatal, and it is seldom, if ever, amenable to treatment. Should opportunity be given for the employment of remedies, ergot and acetate of lead would be indicated, and advantage might be derived from the external application of cold.

In any case of injury of the chest, when fracture of one or more ribs is suspected, but cannot be clearly made out, it is safer to adopt the same course that would be followed if the bone were proved to have given way. The enforced rest will be beneficial if there is mere contusion, and still more so if there is really an undetected fracture.

FRACTURES OF THE COSTAL CARTILAGES are very rare, and not always easily distinguishable from separations at the junction of the cartilages with the ribs. They are apt to be nearly transverse, and are generally due to direct violence.

Reed¹ has reported the case of a man, kicked by a mule, in whom there was separation of the sternum at the junction of the first and second pieces, with fractures of the cartilages of the second, third, fourth, and fifth ribs on the right side, as well as of those of the second, third, and fourth ribs of the left side. The pleural cavities were filled with blood. The right clavicle was also fractured. This extensive injury produced no sign until tympany came on (from rupture of the spleen), and the respiration became of necessity thoracic, with crepitus and displacement of the fragments.

A man was brought to the Pennsylvania Hospital in 1855, who had fallen from a wharf, striking his chest on the edge of a boat. After his death from peritonitis (the colon having been ruptured), it was found that the sixth and seventh cartilages

¹ Proceedings of Path. Society of Philadelphia, vol. ii. p. 47.

on the right side were fractured about an inch from the sternum; the perichondrium was entire in the sixth, but torn anteriorly in the seventh.

M. Broca¹ is reported to have mentioned to the Société Anatomique a case in which the sixth, seventh, and eighth cartilages on the right side were fractured by muscular action. The patient, a porter, had a sack of peas on his shoulder, when another sack was suddenly laid upon him. The weight bore him forward, and in raising himself against it he sustained the injury, the result of which is not stated.

Gurlt quotes from Chaussier the case of an officer, aged 48, who had a diastasis of the cartilage of the left upper false rib, produced by a fit of coughing; there was a hernia of the lung as large as a hen's egg. He cites also Monteggia's account of a very thin man, aged 70, in whom the cartilages of the second and third (true) ribs had been separated from the ribs themselves, also by coughing.

When these fractures do not prove immediately fatal by reason of the damage involved to the thoracic viscera, they may heal like other lesions of the same kind in other parts. Sometimes, however, they result in serious impairment of respiration, and consequently of the general health. Of this the following case affords a good example:—

A cavalry officer² was injured in the right side by a fall from his horse, in July, 1864. Three months later his case was reported as "fracture of the ribs, which have not yet united." In 1870, he was examined by a pension surgeon, who certified that "the sixth and seventh ribs on the right side were fractured and dislocated from the sternum, and, not being properly adjusted, an imperfect cure was the result. There is a projection of two inches outward from the chest at the ends of those two fractured ribs, which are not joined to the sternum. The muscles which move the arm are weakened, and exercise causes pain." Seven years afterwards, it was noted by an examining board that the pensioner had "an anxious expression of countenance; distended nasal alæ; respiration easily disturbed; loud resonance and weak respiration in right lung, indicating emphysema."

Macleod³ mentions the case of a man "hit by a round shot on the edge of the breast-plate, which was so turned inward as to fracture the cartilages of the fifth, sixth, and seventh ribs on the left side, close to the sternum. The skin was not wounded. He walked to the rear, and complained but little for two hours, when he was seized with an acute pain in the region of the heart. His pulse became much accelerated, and he grew faint and collapsed. A distinct and sharp bellows-sound accompanied the heart's action. He died in seventy-two hours from the receipt of the injury, the pain and dyspnoea, which had been so urgent at first, having abated for some hours before death. The heart was found to have been ruptured to an extent sufficient to allow of the finger being thrust into the left ventricle. The obliquity of the opening had prevented the blood escaping into the pericardium, which contained about two ounces of dark-colored serum."

From the cases now quoted, it will be perceived that the injuries in question have much in common with fractures of the ribs.

Union takes place, according to Gurlt, by the formation of spongy bone around both fragments, or in the interspace between their outer walls, the broken ends remaining quite passive.⁴ A number of specimens exist in various museums illustrating this. Gurlt says, on the authority of Malgaigne and Klopsch, that in dogs and rabbits the divided cartilages unite by fibrous or fibro-cartilaginous substances; but that in large animals, as in the horse, the rule is the same as in man.

The *treatment* must be immobilization by means of adhesive plaster. Mal-

¹ Brit. and For. Med.-Chir. Review, Oct. 1856.

² Med. and Surg. Hist. of the War of the Rebellion, Part III. Surg. Vol., p. 649.

³ Notes on the Surgery of the War in the Crimea, etc.; Am. ed., p. 204.

⁴ Interesting and instructive articles on this subject, by Prof. Bennett, may be found in the Dublin Journal of Medical Science for March, 1876, and for October, 1877.

gaigne recommends an instrument like a truss, having a spring carrying two pads, one to be applied over any projecting fragment, the other at the back, and mentions a case in which he employed this apparatus with success.

FRACTURES OF THE STERNUM.—From the spongy structure and exposed situation of this bone, one might expect that it would be very readily broken. Yet such is not the case; it is not often fractured, and very rarely by direct violence. When this does happen, other bones in the neighborhood are apt also to be involved. A good many instances, however, are upon record in which this bone has given way to indirect force, and to muscular action.

A longitudinal fracture of the sternum, produced in a mason who was buried under some heavy stones, was recorded by Barrau, and is quoted by Malgaigne and Gurlt; it is the only undoubted case of the kind, as far as is known. Gurlt quotes two instances of partial fracture of this bone, the posterior surface alone having suffered; hemorrhage had taken place into the mediastinum in each. One, seen by Senator, was from the kick of a horse; the other, by Brotherston, from a fall of about ten feet upon the head.

The following curious case is mentioned by Malgaigne:—

“A man of sixty-three was knocked down by a dray, the wheel of which went up on the left side of the chest, but not getting over the trunk, passed off on to the left arm, which, however, was uninjured. The next day the man came to the hospital; a quite notable swelling occupied the upper sternal region; and the first piece of this bone, with the cartilage of the second rib on each side, made so marked a prominence in front that I thought I had to deal with a luxation, or with a transverse fracture with overlapping. I tried various manœuvres to accomplish reduction, but in vain; effusion occurred in the pleura; an abscess formed above the fracture, and the patient succumbed on the thirty-third day. At the *autopsy*, fractures were found in the semi-ossified cartilage of the first rib on the left side, as well as in the second, third, and fifth ribs of the same side; these had not been suspected at all. The sternum was broken transversely at the level of the third intercostal space, the upper fragment being slightly inclined backward; this fracture also had escaped notice. Lastly, a fracture, situated above and to the left, detached from the bone, as if with a knife, a sort of scale, the base of which reached from the fourchette to the level of the second costal cartilage, comprising all the left sterno-clavicular articulation, and the cutting edge of which was at the anterior face of the bone; the abscess had formed at the seat of this fracture.”

Malgaigne quotes from Duverney a case in which a ten-pin player, who bent forward to watch his ball, fell, striking a large stone; he was taken up dead, with a fracture of the sternum. I must say that this account is not full enough to be satisfactory, as some other lesion must have been present. Gibson¹ says that, in 1839, he saw in the museum of the London University a heart, the right ventricle of which had been lacerated by a fractured sternum; and he cites a like case from Sanson.

A number of instances are on record in which fracture of the sternum would seem to have been caused by the impact of the chin, the vertebræ giving way and allowing the head to be forced forward and downward. Four such cases were observed by Hodgen;² in three of them the patients had fallen backward, striking on the shoulders. Rivington³ mentions a case in which—

“An acrobat, æt. 30, in turning a double somersault, fell about ten feet on to the back of his head. He came down on some tan, and his head was violently flexed on to his chest. The injury caused a separation between the sixth and seventh cervical vertebræ,

¹ Op. cit., p. 253.

² Holmes's System of Surgery, Am. ed., vol. i. p. 752.

³ British Medical Journal, January 31, 1874.

and an oblique fracture of the sternum, such as might have been produced by the chin inclined to one side."

Michael¹ records the case of a seaman who fell into a hold, sustaining a dislocation of the fifth cervical vertebra on the sixth, with fracture of the sternum, the periosteum remaining unruptured in front. Spontaneous reduction of the luxation took place. There was laceration of the lung, and the mediastinum became emphysematous. Death occurred on the third day.

In all the foregoing cases the fracturing force acted directly. Indirect violence may be exerted in either one of several ways: by the forcible bending backward of the trunk, or by falls on the buttocks or on the feet. Malgaigne suggests that some of the fractures ascribed to muscular contraction are really due to the first of these causes—a forcible separation of the upper and lower ribs, carrying with them their respective portions of the sternum. But in all cases, I think, we may exclude the direct pull of the muscles attached to the sternum as causes of its fracture. Gross² gives the following account:—

"In 1838 I attended, along with Dr. Rohrer, a case in a large, heavy, muscular man, forty-six years of age, who had received a transverse fracture of the upper part of this bone, from inordinate contraction of the sterno-cleido-mastoid muscles, in jumping, in a state of intoxication, off a shed eleven feet high. The heels striking the ground obliquely, threw the body violently backward, the head and neck coming in contact with the edge of a board. The fracture was, doubtless, occasioned by the effort which the man made to regain his equilibrium."

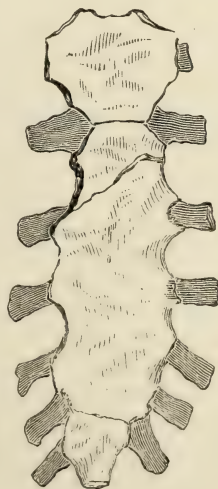
My own belief is that here there was sudden flexion of the body backward, and that the fracture was due to the mechanism before spoken of.

A number of instances have been known in which the sternum has given way to powerful muscular contraction in child-birth. In all of them, as far as I know, the trunk is stated to have been bent strongly backward. Analogous to these cases would be that often quoted from Faget, in which a mountebank, as a feat of strength, was leaning back and trying to raise a weight with his teeth. When the great extent of muscular structure, connected with the ribs, which would thus be put into forcible play, is considered, it can scarcely be doubted that to this, and not to the mere contraction of the muscles attached to the sternum alone, should the production of the fracture be ascribed.

It is not always an easy matter to determine whether the lesion is an actual fracture, or merely a diastasis between the pieces of the sternum; but the question is not one of great practical importance. Occasionally, as in the specimen³ of which Fig. 818 is a representation, the line of fracture clearly runs across one portion of the bone, with a marked degree of obliquity.

Sometimes the displacement is very slight, but it may be considerable; and, in the great majority of cases, the lower fragment projects in front of the upper. Malgaigne mentions one case seen by Sabatier, in which an old man had been subjected to great violence, and thrown into a hole thirty feet deep. He fell on his

Fig. 818.



Fracture of sternum.

¹ Maryland Med. Journal, Sept. 1, 1882.

² Op. cit., p. 956.

³ In the Mütter Museum of the College of Physicians of Philadelphia; the specimen has no known history.

back; the second piece of the sternum was broken away from the first, and driven in behind it.

The *symptoms* of this injury are analogous to those of fractures of the ribs and their cartilages. Pain, tenderness, swelling, and ecchymosis have been noted in all the cases not immediately fatal. Cough almost always occurs, and emphysema may exist independently of injury to the lung. Displacement and crepitus have generally been more or less distinctly marked. Suppuration has occasionally taken place in the anterior mediastinum.

Riedinger¹ says that repair, when it ensues, is effected by means of a layer of fibro-cartilaginous material, placed between two other layers of hyaline cartilage. Very probably this statement may apply to cases of disruption occurring between two of the pieces; but when a true fracture takes place in this bone, it is repaired in the ordinary manner, as may be seen in many museum specimens.

The *treatment* of these injuries does not differ in any material respect from that of fractures of the costo-sternal cartilages. When displacement exists to any marked degree, it should be corrected as far as possible. But while it is eminently proper to make this attempt, it must be remembered that the displacement is not of itself a source of danger. Hammick² says that "if the bone were allowed to remain depressed, it would extinguish life;" but there is no ground for this statement. Hence operative interference, such as the introduction of gimlet-like screws, or of elevators or blunt hooks, for the purpose of pulling or prying up the depressed fragment, is unjustifiable. Moreover, the texture of the bone is too spongy to afford a good hold to such instruments. The only available method of procedure is to act upon the lateral walls of the chest, by causing the patient to alternately fill and empty the lungs to the fullest extent possible to him, and by raising and lowering the arms, while the surgeon tries to push in the projecting fragment.

The deformity having been thus rectified as far as may be practicable, the walls of the chest should be immobilized by means of adhesive strips, applied across their anterior portion, and covering in the whole sternal region. A flannel bandage surrounding the whole thorax may be put on in addition to the strips, and secured so that it shall not slip upward. Should inflammatory or other complications arise, they should be met by appropriate treatment. Absolute rest in bed should be enjoined, and a concentrated diet.

When an abscess forms behind the sternum, if its presence can be clearly made out, there is no positive objection to penetrating the bone in the median line with the crown of a small trephine; but it is almost certain that the pus will find its way to the surface, either at the seat of fracture or in one or more of the intercostal spaces, when vent can be given to it by a simple puncture of the skin.

FRACTURES OF THE PELVIS.

Viewed as a whole, the pelvis constitutes a bony ring, interrupted anteriorly by the pelvic synchondrosis, and posteriorly on either side by that between the sacrum and the ilium. These synchondroses, by the arrangement of the walls and cancellous structure on either side of them, are adapted to diminish the stress put upon the whole framework, either by ordinary or by extraordinary forces. It may further be said that the pelvis presents not only the bony ring just mentioned, which has no great depth below the brim of the lower or true pelvis, but also certain appendages—the iliac expansions

¹ Gaz. Méd. de Paris, 12 Août, 1882.

² Op. cit., p 167.

above, the rami of the pubis and ischium below and on either side, and the downward prolongation of the sacrum and coccyx behind. The ligaments which bridge across the gaps between these appendages add nothing to the security of the bone against fracturing forces. Of the whole framework, the strongest part is that where, in the erect position, the weight of the trunk is transmitted to the head of the femur; the sacrum, although thick, is composed in great measure of spongy bone, further weakened by the perforations for the sacral nerves, as well as by the terminal portion of the spinal canal.

Fracture of the pelvis is not common in men, is rarely met with in women, and is almost unknown in children. The youngest patient I remember to have treated for such an injury was sixteen years old. Bryant, however, mentions two cases seen by him in children, and a few others are upon record. I may mention here that, notwithstanding the rarity of fractures of the pelvic bones, three cases were under treatment at one time in my wards at the Episcopal Hospital, in 1882; a sort of coincidence not unfrequently met with in practice.

Fractures of the appendages may occur without affecting the continuity of the pelvic girdle proper. They are generally due to direct violence. Thus the crest of the ilium may be broken off, in one or more pieces; the lower part of the sacrum may be fractured more or less transversely, or comminuted; or a portion of the ischium may be separated, this, however, being very rare. The lines of fracture vary almost indefinitely, as might naturally be expected.

When a crushing force, such as the caving in of a mass of earth, a fall of rock or of coal in a mine, or the passage of a heavy wheel over the lower part of the body, is brought to bear upon the whole pelvis, the bone may give way at two or more different points. One or the other side of the ring may be especially acted upon, or the stress may be exerted directly across, either antero-posteriorly or laterally. In any case, however, the pubis would seem to yield first, in its horizontal ramus, when there must be a fracture also somewhere between the symphysis pubis and the tuber ischii. Next, if the force acts antero-posteriorly, the tendency will be to open out the lateral are of the bone, which may be broken at or near the sacro-iliac junction. Thus a portion of the sacrum may be torn away, or the lesion may be confined to the os innominatum. Cases of the former kind have been very fully discussed by Voillemier, in two instructive papers.¹ According to him, vertical fractures of the sacrum very generally belong in the category of "fractures par arrachement," or what we should now call "sprain-fractures." That is, by the immense strain brought to bear upon the pelvic ring, the sacro-iliac synchondrosis being too strong to yield, the spongy substance of the sacrum is actually torn across.

The mechanism above described is regarded by Tillaux² as that which uniformly prevails in the production of these fractures; and his view is supported by the fact that in all cases of multiple fracture of the pelvis (and there is no portion of the skeleton so liable to this form of injury), the anterior segment of the ring suffers. The annexed cut (Fig. 819), taken from a specimen (without history) in the Mütter Museum, will give a good idea of the usual characters of this fracture.³

A few years ago I saw a case in which double fracture of the pelvis had been produced by lateral pressure in a somewhat curious way. The man

¹ *Clinique Chirurgicale*, pp. 77 et 107.

² *Traité d'Anatomie Topographique*, p. 829.

³ Kusmin, in an article to which I have not been able to obtain access (*Ueber Beckenfrakturen*, *Centralblatt für Chirurgie*, Jan. 6, 1883; from *Wiener med. Jahrb.*, 1882), gives the results of experimental researches on the mechanism of the production of these fractures.

was sitting in the side window of the "cab" of a locomotive, leaning forward with his buttocks projecting, when it passed through the narrow door of an engine-house, and he was caught and jammed. After his death, it was found that the bone had given way on each side.

Fig. 819.



Multiple fracture of the pelvis.

Occasionally, fractures of the pelvis have been seen as the result of falls on the feet, and even from much slighter accidents. Thus Bouvier¹ recorded the case of a man, aged 71, who met with a slight fall out of bed, and fractured the left os innominatum, from the iliopectineal eminence, down through the acetabulum to the spine of the ischium. Sometimes the force acts directly through the head of the femur upon the adjacent portion of the os innominatum. Hutchinson² records an instance of starred fracture of the acetabulum, the head of the femur being driven through it by a fall on the trochanter. Gama³ reported the case of a man, aged 30, who fell eighteen feet, striking on the trochanter. Death occurred from peritonitis on the tenth day. At the autopsy it was found that there was an abscess extending from the hip to the calf of the leg, and into the iliac region within the pelvis: the acetabulum had been broken into three pieces, the smallest of which was placed with the round ligament upon it, and unbroken, on the head of the bone; the second was the horizontal ramus of the pubis, which was separated from the symphysis pubis and ischium; and the third was the ischium, which was no longer connected with the ilium. Perhaps the most remarkable case is that recorded by Lendrick,⁴ in which, by an accident many years previous, the head of the femur was found to have been driven through the acetabulum, and to be covered in, partly by bone, partly by fibrous tissue; the os pubis had been fractured and united with shortening, entangling a portion of intestine, which remained within a bony cavity as a sort of hernia; the ischium also had been fractured and united.

It not unfrequently happens that the anterior portion only of the pelvis suffers, perhaps at numerous points. Lodge⁵ saw six fractures thus located, as the result of the caving in of a bank of earth upon the patient; and Peaslee⁶ a case in which seven fractures had been caused by the patient being jammed in a narrow space between a railroad car and a platform. Rupture of the bladder had occurred in both cases.

In one instance, reported by Letenneur,⁷ it was claimed that fracture of the pubis had been caused by muscular action; the patient, a woman, was lifting some large stones in unloading a boat, and felt something give way; but as it is expressly stated that, at that moment, she rested a stone, weighing over one hundred and fifty pounds, on the pubis, there must at least be some doubt whether the fracture might not be more justly attributed to the direct pressure thus exerted. Coates⁸ has recorded a case in which the os pubis was fractured in a very analogous way, a coach in which the patient was

¹ Am. Journal of the Med. Sciences, February, 1839.

² Med. Times and Gazette, February 24, 1866.

³ American Journal of the Medical Sciences, May, 1838, from Gaz. Méd. de Paris.

⁴ London Medical Gazette, March, 1839.

⁵ Am. Journ. of the Med. Sciences, Oct. 1865.

⁷ Medical Times and Gazette, November 28, 1868.

⁶ Ibid., April, 1850.

⁸ Med.-Chir. Trans., vol. xi.

travelling having been overturned, and the anterior part of her pelvis having been forced against the seat by the weight of several of the other passengers thrown over upon her.

FRACTURES OF THE ACETABULUM.—Fractures of the *rim of the acetabulum* are by no means uncommon; they owe their importance chiefly to the fact that they are apt to allow the head of the femur to slip out of place, and, although it is easily reduced, it escapes again with equal readiness. A number of instances of this kind are given by Sir A. Cooper,¹ one of which, observed at St. Thomas's Hospital in 1791, is, I think, the earliest on record. McTyer² published several cases; R. W. Smith,³ one; Lonsdale, one; Holmes,⁴ one; Eve,⁵ two; Gurlt⁶ gives a wood-cut, representing a fracture of the upper part of the rim of the acetabulum, which allowed of a very curious luxation—the trochanter major lying in the acetabulum, and the trochanter minor being applied to the outer edge of the tuber ischii.

Favell, in an address before the British Medical Association,⁷ detailed a case which occurred under the care of Mr. Wheelhouse, in which a fracture of the rim of the acetabulum gave rise to subsequent dislocation of the femur upon the dorsum ilii—the symptoms of the latter lesion being manifested only some months after the accident, when the patient got up and bore his weight on the limb. The case became the subject of legal proceedings, but the result is not stated. Morris⁸ has reported an instance of unreduced dorsal dislocation of the femur, with fracture of the rim of the acetabulum, in a young and active man, the displacement coming on gradually during a period of about ten weeks.

The mechanism of this fracture must be sufficiently obvious.

FRACTURE OF THE SACRUM.—Fracture of the *sacrum* by itself is not of common occurrence, although the spongy character of this bone, before spoken of, renders it really the least resistant portion of the pelvis; and occasionally violence is applied to it directly. Lee⁹ has recorded the case of a man in whom, by a fall from a height of forty feet, the sacrum was broken across; the displacement of the lower fragment forward was corrected by means of a finger in the rectum. At the autopsy, “the sacrum was found comminuted, a large fragment of the left ala being broken off longitudinally and displaced to a considerable extent.”

In a very remarkable case reported by Burlingham,¹⁰ the patient, a railroad conductor, was thrown into the air, fell on the top of a car, striking on his back, and then rolled down an embankment a distance of over eighty feet. He sustained a compound fracture of the sacrum, the posterior surface of the bone at least being comminuted; and through the wound in the back, urine flowed for many months.¹¹

¹ Dislocations and Fractures of the Joints, 6th ed. London, 1842.

² Glasgow Medical Journal, February, 1831.

³ Archives Gén. de Médecine, 1838.

⁴ Transactions of Pathological Society of London, vol. xi., 1860.

⁵ Med.-Chir. Transactions, vol. lxiii., 1880.

⁶ British Medical Journal, August 5, 1876.

⁶ Op. cit., Bd. i., S. 320.

⁸ Lancet, February 18, 1882.

⁹ Proceedings of Pathological Society of Philadelphia, vol. ii. p. 116.

¹⁰ American Journal of the Medical Sciences, April, 1868.

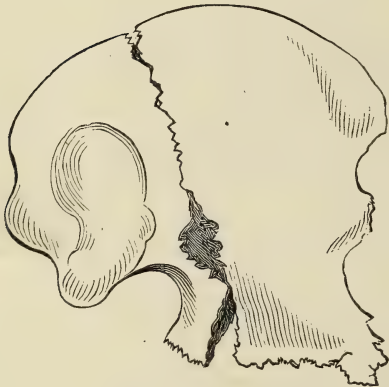
¹¹ In the account of this case, it is stated that about three weeks after the accident “a probe could be passed from about an inch above the base of the coccyx, and about three-quarters of an inch to the right of the median line, across the pelvis, forward and slightly downward, a distance of five inches, until it was obstructed by bone, denuded or fractured.” This fact, taken together with the injury to the bladder, seems to me to indicate that a fracture had occurred anteriorly also; but, as the patient recovered, the diagnosis could not be placed beyond doubt.

FRACTURE OF THE COCCYX is spoken of by authors; but the consolidation of the several pieces takes place only in advanced age, and without this a true fracture could scarcely occur. No unquestionable cases are upon record in which this bone alone has been broken, and the probability is that the lesion involved to the surrounding soft parts would be of far more importance. Should trouble arise in any such cases from inflammatory thickening and contraction of the tissues, it would be proper to divide the latter with the knife; and failing relief from this, excision of the bone might be practised, although the experience recorded by Mursick¹ is not such as to warrant great expectations of success.

A case is reported² in which the coccyx, "fractured and standing at a right angle with the sacrum," was removed by means of the "surgical engine," by Dr. Garretson. The history given of the case is simply that the patient, a lady, had suffered from coccygodynia for thirteen years. The periosteum was incised and laid open so as to expose the bone, which was then drilled away. The ultimate result is not stated.

FRACTURE OF THE CRISTA ILII.—Fracture of the *crest of the ilium* is by no means uncommon. I have seen it caused by a fall from a horse, the patient striking on his hip against some railroad iron piled at the side of the street. At the Episcopal Hospital, in 1882, I had in the wards a man aged 21, who had fallen about twelve feet, striking on a rafter; the left crista ilii, from

Fig. 820.



T-fracture of the ilium.

near the sacrum to a point near the anterior superior spinous process, was broken off. In this case there was, for some weeks, severe pain along the course of the anterior crural nerve; and it seemed probable that its trunk had been pinched or torn.

A rarer form of fracture of the ilium is shown in Fig. 820, taken from a specimen (without history) in the Mütter Museum. The bone has been separated nearly vertically, and transversely as well, the two lines of fracture representing an inverted T.

Hamilton states that he has seen about three inches of the ilium, including the anterior superior spinous process, torn off by muscular action; the patient, a man aged 70, having merely risen from his seat in a railroad

car, when he felt "something wrong." Riedinger³ claims that muscular action plays a much more important part in the production of fractures of the pelvis generally than has been ascribed to it by most writers.

FRACTURES OF THE ISCHIUM alone are very rare, the six cases collected by Malgaigne being the only ones known. Three of them were due to violent falls on the buttocks, and all to direct violence.

Malgaigne has devoted a special section to what he calls "*double vertical fracture of the pelvis.*" This he defines as "a combination of two vertical

¹ American Journal of the Medical Sciences, January, 1876.

² Philadelphia Med. Times, February 11, 1882.

³ Arch. für klin. Chirurgie, Bd. xx. Heft 2: American Journal of the Medical Sciences, April, 1877

fractures, separating at one side of the pelvis a middle fragment comprising the hip-joint; according as this fragment is carried upward or inward, the femur follows its movements, and hence result changes in the length and direction of the limb which have often misled practitioners." An injury of this kind might readily be mistaken, at first sight, for fracture of the neck of the femur, as there would be crepitus, some degree of shortening—although in one case, according to Larrey, there was lengthening—of the limb, and very probably impairment of motion; certainly inability to walk or stand. Careful examination, however, into the precise seat of the crepitus and difficulty of movement would, in most cases, be apt to reveal the true nature of the lesion.

Besides the fractures of the various portions of the pelvis which have been enumerated, there are certain cases of more extensive injury in this region, the whole framework being broken up, as in some mining accidents. I have seen the os innominatum on either side broken through nearly or quite vertically, both anteriorly and posteriorly, making four principal fragments. Such injuries are in themselves extremely grave, from the amount of shock which they involve.

One of the three cases before referred to as treated in my wards at the Episcopal Hospital, in 1882, was that of a laborer, aged 50, upon whom a bank of earth had caved in. The os innominatum on either side had been broken, as above described, close to the sacro-iliac junction, as well as through the os pubis; there were profound shock, retention of urine for several days, and subsequent peritonitis. The man complained of severe pain in the right leg from the hip to the toe; but this gradually subsided along with his other symptoms. As he recovered, the diagnosis above given could not of course be verified beyond question by an autopsy; but the mobility of the fragments, the crepitus, and the long-continued tenderness upon pressure at the points indicated, seemed to warrant my statement of the case.

Another was that of a young man, aged 16, who had fallen about sixteen feet. Pressure on his pelvis from side to side, or over the pubis, caused him great pain, as did also a slight blow on the knee if the thigh was flexed. He suffered less from shock than the patient first mentioned, but had retention of urine for four days. He also recovered.

The *symptoms* of fracture of the pelvis need scarcely be dwelt upon at length. There is always more or less pain, sometimes very severe; it is apt to be greatly aggravated by any attempt at moving in bed. When the sacrum is fractured, the act of defecation is productive of great pain; and urination is similarly interfered with when the pubis has given way. In either case the patient's suffering is increased by coughing or sneezing. Crepitus can usually be felt if pressure be so applied as to cause grating of the fragments upon one another, but it is often by no means distinct. Ecchymosis may or may not be present, as sometimes the fracture affects portions of the bone very deeply situated, and the vessels torn may be at the inner surface. Often the fragments are scarcely at all displaced, and hence no deformity is caused.

It may readily be perceived, therefore, that the *diagnosis* of injuries of this kind may present a good deal of obscurity; and even when the fact of fracture is clearly to be made out, it may be a matter of much difficulty to determine the exact line of separation, especially in stout or fat persons. Examination by the rectum, and in females by the vagina, may enable the surgeon to arrive at greater certainty in this respect. But even the most

careful and thorough exploration may fail to ascertain the full extent of the injury. Malgaigne quotes from Lyon a case in which "seven or eight fractures were discovered by dissection, although no crepitation had been perceptible during life, from any movement whatever of the pelvis." I myself know of an instance in which a fracture of the horizontal ramus of the pubis on each side, of the ascending ramus of the ischium on each side, and of the sacrum vertically, with much comminution of its lower extremity and partial separation of the right sacro-iliac symphysis, entirely escaped detection during life. The urethra was ruptured across, and this lesion caused the patient's death a day or two after the accident.

The gravity of fractures of the pelvis is due to the *complications* apt to attend them, rather than to the injury inflicted on the bone. Several cases have been mentioned in which death was the result of rupture of the bladder or urethra. It is not always easy to explain how the bladder is involved, as in some instances the fracture of the pubis is so far from the median line that the fragments can scarcely be supposed to have lacerated it, unless greatly distended, and still more difficult is it to understand in what way the urethra is torn across. Yet very possibly the fracturing force may greatly displace the fragments, which subsequently are restored to their natural position, or nearly so, by the elasticity of the bony structure; or the urethra may be subjected to violent stress between a foreign body below and the pubic arch above—a supposition rendered more likely by the contused and bruised condition of the tissues of the perineum in some of these cases.

Swan¹ relates several interesting cases of fracture of the pelvis, in one of which two inches of the urethra were found at the autopsy to have been torn away. The patient had fallen from a horse, breaking the right pubis through its body and ramus, and separating it at the symphysis. In another case, the patient having been run over by a loaded wagon, the fracture involved the arch of the pubis, several other portions of the ischium and pubis, the right acetabulum, and the right sacro-iliac symphysis. The bladder had a large rent in its anterior part, and the urethra was torn completely through.

Earle² records a very curious case, in which, by a fall from a carriage, "the symphysis pubis was separated to the extent of three inches, and the sacro-iliac symphysis on the left side was nearly separated and gaped to the extent of more than an inch. The prostate gland had been torn away from the bladder, leaving a large aperture communicating directly with the cavity of that viscus. The urethra still retained its connection with the ligament on the right side of the pubis, and the prostate gland hung loose in a cavity filled with coagulum. An extensive laceration communicated with the rectum."

Fragments of the fractured pubis have been known to make their way into the bladder. Tillaux³ saw such a case, and quotes one from Lenoir, in which the bit of bone became the nucleus of a stone. He mentions also that Nélaton once extracted, through the vagina, a fragment which had wounded the bladder. By mere pressure, a displaced fragment may obstruct the passage of a catheter.

The great vessels are not often wounded in cases of fracture of the pelvis, although it would seem as if they readily might be. Earle⁴ reports a case, in which, by a fall from a third story window, the left os innominatum was separated at the symphysis pubis and sacro-iliac junction, and "was forced upward to a considerable extent. The common iliac vein on that side had been torn through, and the pelvis was filled with blood." The patient, who

¹ Med.-Chir. Trans., vol. xii.

³ Op. cit., p. 830.

² Ibid., vol. xix. p. 257.

⁴ Loc. cit., vol. xix. p. 262.

had sustained other injuries also, died an hour after the accident. Lucas¹ records three cases, in one of which the right internal iliac vein was wounded, while in another the right external iliac artery was divided, and in the third the left external iliac vein was lacerated.

Lente² has reported a case in which the small intestine was wounded by a sharp fragment of the ilium.³

Another danger which occasionally attends these injuries, is that of extensive suppuration. Of this an instance has been mentioned in a preceding page, and others are upon record.

With regard to the *treatment* of fractures of the pelvis, there is not very much to be said, although the subject is one of great practical importance. Absolute rest in bed is generally a necessity clearly perceived by the patient; and his comfort is often promoted by a broad bandage firmly applied around the pelvis, a thick layer of raw cotton being placed next the skin. When there is a tendency to displacement inward of a fragment, as for instance of the iliac crest, the pressure of the bandage may do harm, and it should either be more loosely fastened, or cut away at this part, or even dispensed with altogether.

Shock, if it be present, as it is apt to be in the early stage of the case, should be combated by stimulants—alcohol, carbonate of ammonium, hypodermic injections of ether, and external heat.

If there be any difficulty in urination, the bladder should be carefully emptied by means of the catheter, and, if the urine thus drawn off be bloody, we may suspect a wound of the bladder or urethra. When the instrument cannot be readily introduced, if the patient have not previously been the subject of stricture, injury to the urethra is probably present, and extravasation of urine must be looked for. Upon the first evidence of this complication, free incisions should be made in the perineum.

Wounds of the large vessels are apt to be fatal from internal hemorrhage before there is any clear indication of the nature of the trouble; but, if this could be made out, the obvious course would be to cut down at the usual point, and apply a ligature.

In case of abscess, incisions should be made at such points as to allow of the readiest escape of pus, and the use of drainage-tubes may be of great advantage.

The comfort of the patient is often greatly promoted by the use of a fracture-bed, as the unavoidable disturbance caused by the insertion of a bed-pan is apt to produce pain. Should the treatment be prolonged, the occurrence of bed-sores must be carefully guarded against, although this may be a matter of much difficulty; a water-bed, or air-cushions, may, however, be used with hope of success.

In the cases of "double vertical fracture," before alluded to, it may be necessary to prevent the riding up of the acetabular fragment by applying extension to the foot; and this is to be done by the weight and pulley, to be hereafter described in connection with the treatment of fractures of the femur.

Mention has been made of the influence of muscular action in the production of fractures of the pelvic bones; and if this can be ascertained as a cause of displacement of the fragments, the necessity of obviating it by position

¹ Lancet, March 9, 1878.

² New York Journal of Medicine, January, 1851.

³ The reader will find some interesting and instructive cases recorded by Lidell, in a paper on "Ruptures of Pelvic and Abdominal Viscera," in the Am. Journal of the Medical Sciences for April, 1867; and may consult with advantage a monograph, published in 1851, by Dr. Stephen Smith, on "Rupture of the Bladder."

will be evident. Flexion of the thighs on the trunk, as well as of the body forward, will be indicated in any such case.

A few words may finally be said as to the *prognosis* in fractures of the pelvis. In simple, uncomplicated cases, there may be no grave symptoms from first to last, and entire recovery may take place. When the bladder or urethra has sustained injury, the risk is greatly increased; and the more so the nearer the lesion is to the cavity of the peritoneum. Complete rupture of the urethra has always, as far as I know, proved fatal. Peritonitis constitutes a very serious complication, but, as in one of my cases above mentioned, may yield to treatment. The other concomitant injuries referred to have always hitherto resulted in death.

In non-fatal cases there has sometimes been permanent lameness, but not very great, nor involving serious disability.

Occasionally, when recovery takes place from fracture of the pelvis, unpleasant after-effects manifest themselves. Thus, in the Pennsylvania Hospital Museum, there is a specimen,¹ taken from a man who had been crushed by a moving car, and who was discharged cured, to be readmitted eighteen months afterward; he was then "suffering from severe sciatic pain, but was able to walk with canes, sitting down, however, only with difficulty. An examination rendered it probable that there was a large amount of callus pressing upon the sciatic nerve, with, perhaps, a fracture of the femur. An operation was performed for removing the head of the femur. Subsequent to the operation, suppurative fever or pyæmia supervened, and death followed on the ninth day." The specimen shows "that the pelvis had sustained a fracture, separating the pubic portion of the bone from the ilium, passing from about the sciatic notch posteriorly to the acetabulum. This is firmly united, but along the line of the fracture, extending forward into the acetabulum, and posteriorly covering more than half the sciatic nerve, are abundant, firm, but porous exostoses. From the spine of the ischium is a hook-like projection, partially surrounding the track of the sciatic nerve. At the junction of the ilium and the ramus of the pubis is a groove measuring nearly an inch in depth, which carried the tendons of the iliacus and psoas muscles. The head of the femur cannot be replaced in its socket, and, at the time of the operation, was found resting in the sciatic region."

FRACTURES OF THE CLAVICLE.

The clavicle, by its articulation with the sternum, affords the upper extremity its only fixed connection with the skeleton of the trunk. Its outer end has a seemingly large, but really quite limited range of motion, and is fastened to the scapula, not only by the small acromio-clavicular joint, but by the wide and strong coraco-clavicular ligament.

At its sternal end this bone is thickest; thence to near the middle it is rounded; here it is flattened below, and turns upward; toward the outer end it becomes very broad and flat, curving forward. The degree of curve varies in different bones, as does also the irregularity of shape just noted, and the size and thickness of the whole bone. Besides the double curve, there is a more or less marked double twist in the clavicle.

As to its muscular attachments, this bone is mainly, indeed almost wholly, an intermediate bone; being placed between the clavicular portion of the sterno-cleido-mastoid and the costo-clavicular ligament, the latter being really

¹ No. 1116¹⁵, Catalogue (Supplement), p. 22.

the tendon of origin of the muscle; while most of the remainder of its length is simply interposed between the trapezius and deltoid. The connection of the pectoralis major with it is only accessory. The only muscle which acts directly upon the clavicle itself is the subclavius, and the function of this is rather to limit the mobility of the clavicle, than to impress motion upon it.

Fractures of the clavicle are among those of most frequent occurrence. They are met with at all ages, even in intra-uterine life. In children they are very common; out of 316 cases of fracture treated at the Children's Hospital in Philadelphia, in seven years, the clavicle was affected in 94, or nearly 30 per cent. Between the ages of 15 and 65, according to Malgaigne, the fractures of this bone form about one-quarter of the whole number; and only one-fourth of the patients are females. At a more advanced age, however, he noted that eleven out of eighteen cases were those of women.

By most authors, fractures of the clavicle are divided into those of the inner, middle, and outer thirds of the bone. This, although a convenient arrangement, is not strictly accurate, as some oblique fractures, which occupy the outer portion of the inner third, in part, traverse both this and the middle third. I prefer to speak of fractures of the *body* of the bone, of those near the *sternal* end, and of those near the *acromial* extremity. Fractures of the body of the bone, which may concern the middle third only, or may encroach also upon the inner or more rarely upon the outer third, are by far the most numerous. They are very generally oblique, although occasionally nearly or even quite transverse.

Compound fractures of the clavicle are almost never met with, unless they become so secondarily by a sharp fragment penetrating the skin, which happens extremely seldom; and they are not often comminuted, at least to such a degree as to influence the result. *Incomplete fractures* of this bone have, however, been repeatedly observed, and not a few instances in which, the periosteum being untorn, the fragments have remained in place. Several such, occurring in young subjects, have been recorded by Blandin¹ and Robert,² and a number are quoted by Malgaigne from different authors. Hamilton mentions several seen by himself in adults; one of his patients, a woman, was eighty years old. A number of such cases are on record, in which the fact of fracture has been unrecognized until after the occurrence of union.

Fractures of the clavicle may be caused by *direct force*, as by a blow, by the recoil of a gun, by the fall of a heavy body upon the shoulder; by *indirect force*, as by a fall on the point of the shoulder, or upon the hand; or by *muscular action*, as by the effort to pull down the brace of a carriage-top,³ or in striking a blow with a whip.⁴

In inquiring into the mechanism of the production of fracture under either of these conditions, it must not be forgotten that the inner or sternal end of the bone is firmly fixed, and that, as before stated, the range of motion of the acromial end is but limited. There is another anatomical fact, pointed out by me many years since,⁵ which I believe to be of much importance in connection with this subject. It is the close relation which often subsists between the clavicle and the first rib; by reason of which, when the outer end of the former bone is forced downward, the bone itself becomes a lever of the first order, the rib being the fulcrum. In some persons the upper part of the thorax comes much more nearly to a point than in others, the arch of the

¹ Am. Journ. of the Med. Sciences, April, 1843; from Journal de Méd. et de Chir. Pratiques, Juillet, 1842.

² Ibid., Jan. 1859; from L'Union Médicale.

³ Hamilton, op. cit., p. 193.

⁴ Parker, New York Journal of Medicine, July, 1852.

⁵ New York Medical Journal, Oct. 1866.

first rib being smaller, and the bone itself more delicate. Again, in some persons the clavicle is much straighter, and stands out more directly from the sternum than in others. I think that these two conditions usually correspond. When the first rib forms a wide and strong arch, and the collar-bone runs somewhat backward as well as closer to the rib, the two bones may even be almost in contact as far nearly as to the middle of the clavicle. In such a case, a blow, the recoil of a gun, or any force driving or dragging the outer portion of this bone downward, or downward and backward, would act on the bone as a lever, and tend to break it at any point where it might be weakest. The rib, being a strongly stayed arch, pressed upon at its convexity, would not give way; while the clavicle would be at a disadvantage, being subjected to a force at its concavity, tending to increase its curvature. I think that this was clearly the mechanism of the following case, mentioned by Malgaigne: "I have seen an incomplete fracture of the clavicle resulting from the pressure of a burden which slipped from the shoulder down on the arm, and thus, pulling downward on the outer end of the bone, bent and broke it at about the middle."

Very possibly this leverage over the first rib may have something to do with some fractures by indirect violence, as when a man falls forward on his outstretched hand, and the scapula, forced backward by the head of the humerus, carries the acromial end of the clavicle along with it.

There are cases in which it would seem that the clavicle is broken by the forcing upward of its acromial end; and these can only be explained by the firmness of its ligamentous attachment to the sternum, and the unyielding character of the rhomboid or costo-clavicular ligament. Perhaps, however, more accurate information as to the circumstances would set this theory aside. Often the surgeon has to be content with very vague statements on the part of the patient or his friends, and caution is needful in drawing conclusions from premises which may be wholly or in part incorrect.

When the clavicle gives way to a force acting at its outer extremity, as in the case of a fall on the point of the shoulder, it may be easily seen that the mechanism is simply the exaggeration of the normal curves, carried so far as to overcome the resistance of the bony structure. And the more suddenly the stress comes, the more likely is the bone to be broken. The point at which the fracture shall occur is determined by the exact direction of the force, and perhaps in some degree by the action of the muscles at the moment. But in the very large majority of cases the line of fracture runs obliquely through the body of the bone, from within outward and from before backward. The relation of the obliquity to the upper and lower surfaces, I do not know; it is probably not a constant one.

Symptoms of Fractured Clavicle.—Upon the occurrence of fracture of the clavicle, if the periosteum yields, there is generally marked *displacement*. And this may be either a mere prominence of the inner fragment, or a positive projection, the outer fragment being carried behind the inner so as to make the latter start forward. This is the almost universal rule; but cases have been observed in which the outer fragment has been in front of the inner. The annexed cut (Fig. 821) represents the clavicle of a patient in my wards at the Episcopal Hospital in 1882, in whom the outer fragment was directly below the inner. The man was a German teamster, and said he had fallen down, striking his shoulder; he could give no details of the accident, and at the time when I saw him there was no bruise or other indication of the exact point of impact. The complete reduction of the fracture was impossible, but a good recovery ensued, with some superabundance of callus. I

cannot offer any explanation of these exceptions; but it will be seen that in my case the fracture involved the sternal third of the bone.

Sometimes, when the cause of the fracture has been direct violence, it is sufficiently obvious that the outer fragment has been driven back from the

Fig. 821.



Fracture of clavicle with downward displacement of outer fragment.

inner. But there must be a further reason for the very general existence of this displacement, and I believe it is to be found in the changed position of the scapula. Upon the loss of the stay afforded by the unbroken clavicle, the serratus magnus and pectoralis minor muscles pull the scapula forward and inward, while perhaps the rhomboidei muscles draw up its lower angle. The acromion is thus brought nearer to the median line, and tilted downward; the effect of which is to push the distal fragment of the broken clavicle inward, and to depress its outer end. This seems to me to afford an ample explanation of the very constant occurrence of this form of displacement. Very possibly the fibres of the subclavius may also draw upon the outer fragment, and aid in the production of the deformity. The forcing of the outer fragment behind the inner will tilt the latter upward and forward; and my belief is that to this, and not to the action of the clavicular portion of the sterno-cleido-mastoid, is due the projection of the inner fragment so commonly present. The action of the last-named muscle, indeed, is from below upward (the Germans call it "*Kopf-nicker*," that is, head-nodder), and through the rhomboid or costo-clavicular ligament it gets an origin from the first rib. This ligament would of itself prevent the drawing up of the inner fragment, unless, as sometimes happens, it should be itself ruptured.

By all authors we are told that the shoulder falls forward, inward, and downward, and that this displacement is due to the weight of the shoulder and of the upper extremity. It is true that the shoulder does thus change its position; yet the muscles which support it are not impaired, and the mere lifting of the weight does not remedy the deformity. When the scapula itself is drawn back into position, and only then, does the outer fragment of the clavicle resume its normal relation to the inner.

The explanation now given of the cause of deformity in fracture of the clavicle finds strong confirmation, I think, in the condition observed when the bone is broken near the acromial extremity. Here the short outer fragment is pushed round forward and inward, so as to form almost or quite a right angle with the inner, the broken end of the former even coming in contact with the anterior wall of the latter. Many museum specimens exist in proof of this statement, and two such are in the Mütter collection in this city. Malgaigne mentions two cases of fracture very near the acromial end, in which union had taken place. In each of them, "the shoulder was depressed, and carried forward and inward; . . . and to this inclination of the shoulder there corresponded posteriorly a notable prominence of the inferior angle and posterior edge of the scapula." Both the patients had perfect motion of the arm, except backward. Here it seems to me quite plain that the change of shape is to be accounted for as follows: partly by the action of the clavicular part of the trapezius, drawing up both fragments, and favored in so doing by its attachment to the natural convexity of the bone; partly

by the tilting upward and backward of the lower angle of the scapula by the rhomboideus major muscle, aided by the weight of the arm dragging on the upper and outer angle of the bone, and through the acromion on the outer end of the clavicle; but chiefly by the serratus magnus and pectoralis minor carrying the whole scapula forward and inward around the side of the thorax, and thus bringing the outer fragment into exactly the position described with regard to the inner.

A case mentioned by Malgaigne so strongly illustrates the theory now stated, that I venture to quote it at length:—

The patient had sustained a fracture of both clavicles by a fall from a window fifteen feet high. Non-union had occurred in both bones, and the impairment of function was such that he could not resume his former occupation as a tinsmith, but became a tailor.

“Both clavicles had been broken at the middle; the two inner fragments were nearly horizontal, and very distinct beneath the skin; the outer fragments had also a nearly horizontal direction, but were buried behind and below the others, to which they seemed to have no adhesions of any kind. The overlapping was considerable.

“When he stood up the two shoulders seemed lower, as well as carried further forward and inward, than in a healthy person. The one on the right side was higher, and at the same time closer to the sternum, than the other. Posteriorly the scapulæ were separated from the spinal column by three or four inches, and inclined forward and outward; and, on the whole, the thorax seemed contracted at its upper part.

“He could draw the shoulders back a little, but not enough to overcome their apparent prominence anteriorly. On the other hand, he could draw them together forward so that they seemed like wings covering the chest, and leaving between them, in front of the sternum, only three inches of space. In this movement the scapulæ *fitted to the sides of the trunk*, and the back seemed rounded from one side to the other, almost like that of a skeleton deprived of its upper extremities. The shoulders could be raised also at will, but not to any extent, from want of muscular power.”

Professor Gordon, of Belfast, has expressed¹ views in regard to the displacement in fractures of the clavicle, exactly the same as my own. As he has not referred to my paper, I presume that he is not aware of its existence. Though these views have not as yet received the general assent of surgical writers, my belief is that they are correct, and that they will ultimately obtain acceptance.

Prof. Moore, of Rochester, N. Y.,² regards the relaxation of the clavicular fibres of the pectoralis major muscle, and the consequently unopposed action of the sterno-cleido-mastoid, as the great cause of the displacement; but it does not seem to me that this view is tenable.

I say nothing of rotary displacement, because nothing of the kind has ever occurred in the cases under my notice, and I do not think it exists.

Pain is an almost constant symptom of fracture of the clavicle. When the line of separation is oblique, as in most cases, this is obviously due partly to the pressure of the ends of the fragments, especially of the inner, against the skin. According to Tillaux, it is the filaments of the supra-clavicular nerve, in the platysma myoides muscle, which are thus irritated; but the fact that there are often pain and numbness down the arm, and even in the fingers, affords proof that the large trunks of the brachial plexus are also interfered with. In order to obtain relief, patients are very apt to assume a position which, by some authors, has been considered almost a diagnostic sign; they support the arm of the injured side by placing the other hand under the forearm, and incline the head toward the affected shoulder.

¹ Dublin Quarterly Journ. of Med. Science, Nov. 1859. Also in a Treatise on Fractures of the Lower End of the Radius, on Fractures of the Clavicle, and on the Reduction of the Recent Inward Dislocations of the Shoulder-joint. London, 1875.

² Trans. of Med. Soc. of State of N. Y., 1870, p. 107.

Swelling is very apt to occur, especially in fractures caused by direct violence, and attended with much bruising of the soft parts; but it is not often so marked as in some other regions, nor does it generally mask the condition of the bone so completely, by reason of the small amount of subcutaneous areolar tissue existing here.

Echymosis may or may not be present, according to the character of the fracture and the amount of injury to the small veins of the skin. It is very rare to have the deep staining of the surface, coming on slowly and very gradually subsiding, which is often met with in the case of the larger bones.

Crepitus is very generally to be felt. It suffices to gently press the point of the shoulder forward, the fingers of the surgeon's other hand being lightly laid over the bone, to develop a sufficient sound. Sometimes, indeed, this is the only symptom present. M. Guérin¹ has reported the case of a man aged 60, whose clavicle was broken by a fall of earth. During life the only positive symptom of the injury was slight crepitus. After the patient's death (from pneumonia) the fragments could be made to project by means of the finger passed behind the bone.

Along with the crepitus, and shown by the same manœuvre, there is often perceptible an abnormal *mobility* at the seat of fracture. The degree of this will be dependent upon the completeness, not only of the fracture, but of the tearing of the periosteum, as well as upon the direction of the line of breakage, and often upon the amount of serration of the fragments. But whether slight or otherwise, it is an unmistakable proof of the character of the lesion.

Fractures of the *sternal portion* of the clavicle are much less frequent than those of the acromial extremity, and very rare indeed as compared with those of the body of the bone. They have attracted but little notice, an article by Delens² being the fullest source of information in regard to them up to the present time. This author states that while they have been observed as the result of both direct and indirect violence, muscular action is by far their most frequent cause. One instance of the latter kind has been reported by Heath:—³

A boy of fourteen, "whilst raising his arm violently to bowl at cricket, felt something give way at his collar-bone. The inner end of the clavicle was found to be unduly prominent, and presented a sharp edge beneath the skin, quite unlike the smooth end of a bone covered with articular cartilage. The supra-sternal notch was quite distinct, and equally defined on both sides, and a thin lamella could be felt on the right side, intervening between it and the gap caused by the starting forward of the inner end of the clavicle. The treatment consisted in laying the patient down, when the bone at once dipped into place, and was retained by a plaster-of-Paris bandage." This cannot have been, as was suggested, a separation of the epiphysis, since no such formation takes place, according to anatomists, before the twentieth year; and perhaps it might more correctly be placed under the head of sprain-fracture.

Of fractures by indirect violence, the clearest instance is that recorded by Willis:—⁴

A man, aged 54, slipped off a hay-rick, falling on his outstretched right hand, and striking his right shoulder. On examination, there was discovered a simple fracture of the right clavicle within a quarter of an inch of the sternal head of the bone. The direction of the fracture was obliquely downward and outward. The outer fragment was tilted up, partly by the direct action of some of the fibres of the sterno-cleido-mastoid, partly by the weight of the arm dragging the acromial end downward; it was very sharp, and threatened to pierce the skin. Much difficulty was experienced in coaptation of the ends, which could only be fully effected by strongly raising the arm—

¹ Gaz. Hebdom., 20 Sept. 1867.

³ Brit. Med. Journal, Nov. 18, 1882.

² Arch. Gén. de Médecine, Mai, 1873.

⁴ Lancet, Dec. 2, 1882.

a position which the patient either could not or would not long tolerate. A sling, and a compress over the clavicle, were employed; and a year subsequently, the sharp fragment had been greatly rounded, and fibrous union had occurred.

Willis thinks, and with reason, that in this case the rhomboid or costo-clavicular ligament was ruptured.

A case has been published¹ (without the reporter's name) as occurring at the Mount Sinai Hospital, in New York, in which the clavicle was broken about an inch from the sternum. The cause of the injury is not mentioned; but it is stated that the inner fragment was vertical, and the other "down upon the chest." The deformity caused no inconvenience, and was not remedied. The reporter ascribes it to the action of the sterno-cleido-mastoid. I quote this report, notwithstanding its vagueness, because it seems to me to be illustrative of the proper division of these injuries; the lesion was really, although near the inner end, simply a fracture of the body of the bone, in which the displacement was of the ordinary kind, and due to the same causes as before mentioned; but was exaggerated by the shortness of the inner fragment. Possibly, the rhomboid ligament being torn, the muscle may have contributed to the elevation of the inner fragment, but I do not think it alone could have produced it.

The view I wish to maintain is, that the mechanism of fractures of the inner third of the clavicle is the same as that of fractures of the middle third, and that the displacement occurs in the same way; and hence I would simply class them with fractures of the body of the bone.

Fractures involving the sternal end of the clavicle are, however, distinguished by certain features, as may be readily seen in the instances before quoted from Heath and Willis. Lonsdale² mentions the case of a boy, aged 3, who fell and struck his shoulder against the edge of a step, fracturing the clavicle about half an inch from the sternum; he says that "the crepitus of fracture could be distinctly felt, and the end of the bone moved from its natural position."

Fractures of the *acromial* extremity of the clavicle embrace all those which affect the bone anywhere between the acromio-clavicular joint and the inner edge of the coraco-clavicular ligament. They may be caused by direct or indirect violence; it is difficult to see how they could result from muscular action, and I know of no record of any such case. Indeed, the clinical history of these lesions is very meagre; but specimens in which union has taken place are by no means rare. Ossification of the coraco-clavicular ligament, more or less complete, has been noted in some of the cases.

It has been already stated, in speaking of the mechanism of fractures of the body of the clavicle, that the condition observed when the outer third of the bone is broken, is dependent upon the dragging forward and inward of the scapula, by the action of the serratus magnus and pectoralis minor muscles.

Occasionally the clavicle is broken at more than one point. Malgaigne mentions and figures a remarkable specimen, without history, in which one fracture is near the sternal end and the other near the acromial. He speaks of the case of a little girl who had a double fracture, the middle fragment, less than an inch in length, being tilted up in a vertical position between the others, so that it could not be reduced. Conner³ says that he obtained at an autopsy, at the Charity Hospital at New Orleans, "a right clavicle which had been broken in two places, the union being ligamentous at both."

Simultaneous fracture of *both clavicles* has sometimes been met with. One case recorded by Malgaigne has already been quoted, in illustration of the

¹ New York Med. Journal, Jan. 1877.

² Op. cit., p. 206.

³ Holmes's System of Surgery, Am. ed., vol. i. p. 848.

mechanism of the displacement. Gurlt gives fifteen, all produced by very great violence. Besides these, Lane,¹ Burr,² and Wight³ have published cases of the kind. Wight's patient had good union in the bone of the left side, but only ligamentous in the right; yet he could work as well as ever. These cases have a special interest, to be further referred to, in view of the difficulties presented in their treatment.

Diagnosis.—The diagnosis of fracture of the clavicle is for the most part easy; the attitude of the patient, the loss of power in the arm, the seat of pain, the projection of the fragment or fragments which can often be both seen and felt, the crepitus, and the abnormal mobility—all these signs, with the history of a fall on the hand, or on the point of the shoulder, or of violence applied to the part, or of stress put upon the bone by sudden muscular exertion, will generally lead even a non-professional person to a true construction of the case.

When, as in transverse fractures, with little or no displacement, deformity is wanting, pain is slight, and crepitus is hardly to be perceived, the existence of tenderness at a special point, developed either by direct pressure or by a push or tap on the acromial end of the bone, should suffice to indicate the nature of the injury.

The caution given in regard to some other cases, as to undue zeal in the eliciting of symptoms, may be emphasized here; as there are instances on record in which, in able hands, incomplete fractures have been made complete, of course increasing the risk of deformity. Should there be any doubt, it would be right to treat the case as one of fracture; keeping the arm and shoulder at as perfect rest as possible, and watching for the occurrence of more positive symptoms.

Complications.—Examples of complicated fracture of the clavicle, although not by any means of frequent occurrence, have been often enough recorded to make it surprising that Malgaigne should have known of no such cases.⁴ These complications may consist in injuries of the artery, veins, or nerves; of the lungs; or of other bones. They may ensue immediately, or may be among the later phenomena; and they differ greatly in the degree of their gravity, of the suffering which they cause, and of their amenability to treatment.

Evans⁵ reports a case in which an aneurism of the *innominate artery* was ascribed to a fracture of the right clavicle sustained by the patient, a sailor, many months before he came under surgical observation. Dupuytren is said by Delens⁶ to have given, in a clinical lecture in 1831, several cases of aneurism from a like cause.

Injury of the *veins* is somewhat more frequent. Holmes⁷ says, "I have once seen death result from this injury in consequence of the fragment having lacerated the internal jugular vein." Hulke and Flower⁸ mention a specimen (perhaps from the same case) of like injury. They also refer to the case of Sir Robert Peel,⁹ in which there was "a comminuted fracture of the left clavicle, below which a swelling as large as the hand could cover, and which pulsated synchronously with the contractions of the auricles of the heart,

¹ Lancet, July, 1876.

² Medical Record, May 6, 1882.

³ Med. Gazette (New York), 1882.

⁴ Op. cit., p. 471; translation, p. 382.

⁵ Transactions of Pathological Society of London, vol. xvii. 1866.

⁶ Arch. Gén. de Médecine, Août, 1881.

⁷ Surgical Treatment of the Diseases of Infancy and Childhood, 1st ed., p. 248.

⁸ Holmes's System of Surgery, 2d ed., vol. ii. p. 769; Am. ed., vol. i. p. 848.

⁹ Lancet, July 6, 1850 (editorial article).

formed." It seemed probable, from the pain, that some cords of the axillary plexus had also been injured.

Boone¹ reports a case in which a fragment from a comminuted fracture of the clavicle produced somewhat serious symptoms by pressure upon the subclavian vein and adjacent nerves. Erichsen² gives a similar case, in which, however, death ensued from gangrene of the arm. Maunoury³ records an instance of fracture of the clavicle with rupture of the subclavian vein; great swelling having occurred, an incision was made, and death immediately resulted from hemorrhage and entrance of air into the vein.

Of injuries of the *nerves* a good many instances are recorded, only a few of which need be quoted here. Gibson⁴ saw a young man, who had sustained a comminuted fracture of the clavicle by direct violence; "the fragments had been driven behind and beneath the level of the first rib, and so compressed the plexus of nerves as to wedge them into each other, and by the subsequent inflammation to blend them inseparably together. Complete paralysis and atrophy of the whole arm ensued." The patient desired to obtain relief by operation, but Gibson deemed the chance of success too small, and declined to attempt it. Surgeons of the present day would probably have taken a more hopeful view, and cases will be hereafter mentioned in which operative interference has been attended with good results.

Chalot⁵ reports that "in the case of a man of 35, disturbances of innervation showed themselves in the right arm as a result of fracture of the clavicle. Beginning with a sensation of deadness, formication, and pricking, particularly in the palm of the hand, the affection went on to extreme anæsthesia. Very slight irritation of the finger-tips, or the hollow of the hand, or somewhat greater movements of the flexor surface of the forearm, brought on nausea, gagging, and vomiting, with occasional severe diaphragmatic cramp and thoracic oppression (Beklemmung). The patient became first pale, then red; a cold sweat covered the forehead on the affected side. Irrigation with cold water caused the symptoms to appear to a more marked degree, while warm water made them milder. The extremity became smaller, colder than the healthy side, the skin everywhere dry except in the hollow of the hand, there wet with perspiration. The muscles reacted weakly. Pressure upon the branches of the nerves brought on swimming in the head and faintness. Pressure upon the callus at the point of fracture of the clavicle, which had united with considerable deformity, was quite painful, and gave rise to diaphragmatic cramp. Pressure upon the nerves of the face, throat, and nape of the neck, on the affected side, caused similar symptoms." The further history of the case is not given.

Gross⁶ mentions a case of partial paralysis of the upper extremity, with atrophy and permanent contraction of some of the muscles, in a boy of fifteen, the clavicle having been broken by the recoil of a shot-gun four months and a half previously.

Delens⁷ records a case in which the superabundant callus of a fractured clavicle (two ribs also having been broken) exerted such pressure on the subclavian vessels and nerves as to impair the nutrition and muscular power of the limb. Relief was afforded by a subperiosteal resection. Two other instances, in which resection of the fragments was practised, one observed by Gosselin and the other by Perier, are referred to in this article.

Perhaps it may be remarked here that care is to be taken not to confound

¹ Medical Record, November 15, 1873.

² British Medical Journal, June 7, 1873.

³ Progrès Médical, 1882, tome x. p. 302. Reference is here made also to a monograph by Champomier, "Contribution à l'étude des lésions des troncs veineux de la base du cou dans les fractures de la clavicle." Paris, 1882.

⁴ Op. cit., vol. i. p. 254.

⁵ Philadelphia Medical Times, March 27, 1880, from Centralbl. für Chirurgie.

⁶ Op. cit., vol. i. p. 946.

⁷ Arch. Gén. de Méd., Août, 1881.

nerve-lesions due to the original injury with those which may be brought on by the pressure of apparatus, as pointed out especially by Hamilton, and to be further discussed in connection with treatment.

Wound of the *lung* is said to have been several times noticed in connection with fracture of the clavicle, but I am not aware that it has ever been verified by an autopsy except once. Hammick¹ speaks of a man who had had a fracture of the clavicle three days before he came under observation; he died of pneumonia, and on dissection it was found that the fractured portion was so depressed as to have wounded the pleura and torn the lung. Gibier² reports a case in which the acromial fragment wounded the lung, and produced emphysema; the patient recovered, but with non-union of the fracture. Mercier³ gives a similar case, and refers to several others.

The uncertainty in all these cases in which recovery takes place, is not with regard to the wound of the lung, which is sufficiently established by the occurrence of emphysema, and occasionally by hæmoptysis, but as to the mode of its production—whether there is not a fracture of a rib as well as of the clavicle. It is not, however, a matter of serious importance; the relation of the apex of the lung to the clavicle is, in most persons, such that a wound of the former might readily occur by a fragment of the broken bone.

The complication of fracture of the clavicle with that of *other bones* sometimes presents itself. It is chiefly of interest in connection with treatment, and will be considered under that head.

Prognosis.—As a general rule, the prognosis in fracture of the clavicle is favorable. Union takes place, in children especially, with great rapidity. Berry⁴ states that in six cases, the ages ranging between five months and five years, the clavicle was found united firmly in from nine to fourteen days; the longest time being noted in the youngest child. Bouchut⁵ says that Cloquet saw, at the Hospice de l'Humanité at Rouen, a broken clavicle in a girl aged six, consolidated on the ninth day. In adults, consolidation takes place more slowly, averaging perhaps twenty-five or twenty-eight days.

Non-union is sometimes met with, as has already appeared in the preceding pages; but it is not by any means as common as in some of the other bones. A case is mentioned⁶ of “a girl aged nine, who had broken her clavicle a month before, and had had no treatment; the sternal fragment projected upward at an angle of 45°, its sharp extremity forming a visible prominence in the side of the neck. The other fragment was fully an inch below this, and connected with it by what appeared to be a band of fibrous tissue, passing nearly vertically between them.” Even when the fragments fail to become solidly united, the usefulness of the arm seems to be but little impaired, according to the testimony of Hamilton and others.

As to the avoidance of deformity after fractures of the clavicle, it must be confessed that perfect success is very rarely obtained. In almost every instance there remains a perceptible projection of the inner fragment, even after time enough has elapsed for the disappearance of all swelling due to callus; and in some cases the deformity thus produced is very marked. But as a general thing the complete restoration of the usefulness of the limb is not interfered with, although Hurel⁷ assigns the shortening of the bone as the cause of the loss of power sometimes noted. Every experienced surgeon,

¹ Op. cit., p. 159.

² Bull. de la Soc. Clinique de Paris, 1881.

Thèse de Paris, “Des complications des fractures de la clavicle, et en particulier de la blessure du poumon,” 1881.

⁴ New England Medical Monthly, March 15, 1883.

⁵ Op. cit., p. 757.

⁶ Holmes's System of Surgery, 2d ed., vol. ii. p. 766; Am. ed., vol. i. p. 846.

⁷ Considérations sur les Fractures de la Clavicle. Paris, 1867.

however, has seen old fractures of this bone united with great overlapping, but with no apparent weakening of the member.

The amount of injury done to the soft parts can scarcely be left out of the account in forming a prognosis, since bruising of the large nerve trunks passing beneath the bone may interfere seriously with the nutrition and functions of the arm and hand, perhaps even permanently. Of this there is obviously most risk in fractures due to direct violence.

Treatment.—The treatment of fractures of the clavicle is a subject upon which a great deal has been written, and a vast amount of study expended. Hamilton justly says, in regard to the varieties of apparatus: "A catalogue of the names only of the men who have, upon this single point, exercised their ingenuity, would be formidable, nor would it present any mean array of talent and of practical skill."

I shall endeavor to set forth the principles involved, and the means devised for carrying them out, as briefly and clearly as possible, referring the reader to other sources for more detailed descriptions of such contrivances as are not now in general use. Cases occasionally do well even without any treatment at all. Newton¹ has recorded one in a soldier, and Porter² one in a doctor; in each the result is said to have been "good."

As in the case of other fractures, the treatment of the broken clavicle consists in its reduction, or the correction of the deformity, and in keeping the fragments in proper position until their union is accomplished. The first of these processes varies greatly in the degree of difficulty attending it in different cases; being sometimes effected with the utmost readiness, while it is occasionally impossible. Oblique fractures, as a general rule, are more easily reduced than transverse; and those attended with but little irregularity of the ends of the fragments, give less trouble than those in which they are deeply serrated. When the displacement is readily overcome, however, it is apt to be as readily reproduced; or, in other words, the difficulty of reduction and that of retention are inversely proportionate.

Some writers, and Malgaigne among them, have described various modes of procedure for the replacement of the fragments; such, for example, as for the surgeon to apply his knee between the patient's shoulders, while with his hands he pulls the shoulders backward. Unless the views I have presented as to the mechanism of the displacement are at fault, manœuvres of this kind are needlessly forcible; and in my own experience I have found that reduction is best effected by grasping the scapula, and bringing it back around the thorax toward the median line. Generally it will be found that as the acromion is thus shifted it carries with it the outer fragment of the clavicle, and that the line of the latter bone is restored.

When the patient is very muscular, or the fragments are strongly interlocked, it may be well for the surgeon to commit the management of the scapula to an assistant, and to employ his own hands in gently moulding and pressing the fragments, which will often yield to this coaxing process, and the bone will thus resume its normal shape. Such a procedure is especially applicable to fractures seated at or close to the sternal end of the bone.

By most authors it has been laid down as the great principle of treatment of fracture of the clavicle that the shoulder must be carried upward, outward, and backward. My only objection to this statement is that it is not quite precise enough; it is the *acromion*, upon the position of which the retention of the fragments must depend. That this is quite a different matter may be readily shown.

¹ Medical Record, March 4, 1882.

² Ibid., April 8, 1882.

Let a pad be put into the axilla, and pushed up so as to carry the shoulder upward and outward, while the elbow is brought strongly forward so as to bear across the pad, and by leverage to carry the shoulder backward; all this can be done with a sound clavicle, and the change in the shape and position of the shoulder *apparently* effected. But, in fact, all that has been done is to put the soft parts on the stretch; the head of the humerus, and this only, has been forced outward and backward, the capsular ligament of the joint and the muscles yielding before it, while the folds of the axilla are pressed upward by the pad.

When, however, the scapula is grasped and drawn around backward, toward the median line, it will be found that the sound clavicle must follow it; and the motion will be checked as soon as the acromial end of the latter bone has reached the limit of its range.

I feel assured that the recognition of this principle and its application to the treatment of these fractures, will lead to the securing of better results than have been hitherto obtained. Indeed, as I shall presently try to show, the apparatus employed in these cases is often capable of effecting only the apparent change above referred to in the shoulder, and does not act upon the broken bone at all.

When a patient with a broken clavicle is laid flat on his back on a firm and even mattress, it will often be found that the deformity disappears simply by reason of the pressure on the posterior border of the scapula; sometimes, however, this must be aided by the hand of the surgeon bearing backward (downward) against the injured shoulder, or pushing the head of the humerus inward (toward the median line). Advantage has been taken of this fact, and, in a number of cases, cures without deformity have been obtained by simply keeping the patients on their backs in bed until union has occurred. The irksomeness of this plan of treatment, and the difficulty of carrying it out, are sufficient objections to it in all but exceptional cases. Women will sometimes undergo it for the sake of avoiding an unsightly lump on the neck; but for the most part patients prefer the application of apparatus with which they can move about, and pursue some at least of the ordinary avocations of life.

Much the same principle has been had in view in all the forms of back-splint, from the *croix de fer* of Heister (or Arnaud) to those of Keckeley¹ and Grewcock.² It appears also, but somewhat modified, in the figure-of-8 bandages and other appliances for drawing the shoulders together at the back.

In modern times the tendency has been to depend upon bandages and slings of different forms, with or without axillary pads. Of these, that of Desault, although cumbersome, difficult of application, and apt to become disarranged, long enjoyed a confidence due rather to the prestige of its author's name than to its own merits; it has now been superseded, and its description, which may be found in many works of easy access, need hardly be repeated here.

Mayor³ proposed a very simple dressing, which may answer a good purpose as a temporary resource, but is scarcely to be relied upon as a permanent mode of treatment. It consists of two triangular pieces of linen; the elbow being carried inward and forward, one triangle is applied over it, its base upward, and corresponding to the level of the lower third of the arm, its point hanging below and in front of the elbow; the two ends are carried round the chest, and meet to be tied or pinned at the sound side. The point of the triangle is now brought up, passed between the arm and the chest, and drawn strongly upward toward the sound shoulder. Now, the middle of the second triangle

¹ American Journal of the Medical Sciences, Nov. 1834.

² British Medical Journal, Nov. 7, 1868.

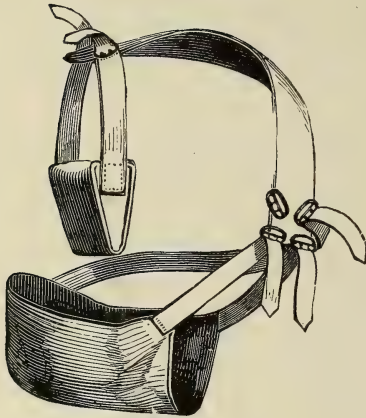
³ Nouveau Système de Délégation, etc. Zurich, 1833.

is sewed to the portion of the first which is behind the back, and its ends are brought up over the shoulders, one to be tied to the point of the first, and the other to come over the broken clavicle and down to the base of the first triangle, to which it is firmly fastened.

Fox's apparatus, which has been extensively used in the United States since 1828, and is still employed by many surgeons, consists of a padded ring for the sound shoulder, an axillary pad of wedge shape, and a sling for the elbow of the injured side; the pad and sling being furnished with tapes in front and behind for attachment to the ring.

Levis's apparatus¹ (Fig. 822), is constructed on the same principle, but

Fig. 822.



Levis's apparatus for fracture of the clavicle.

the padded ring for the sound shoulder is dispensed with, a band over the back of the neck and front of the sound shoulder being substituted for it. To this the elbow-sling is attached by a band across the patient's back, and two across the chest. Dr. Levis uses straps and buckles instead of tapes, and keeps the elbow by the side—not drawn forward.

Professor Moore has proposed² a bandage, which he calls "the figure-of-8 of the elbow." He keeps the arm parallel to the axis of the body, with the elbow close to the trunk, and uses "a shawl or piece of cotton cloth, which when folded like a cravat, eight inches in breadth at the centre, should be about two yards long. Placing this at the centre across the palm of the surgeon, he seizes with this hand the elbow of the patient which corresponds with the broken clavicle. The

two ends of the bandage hang to the floor. The one falling inward toward the patient is carried upward, in front of the shoulder and over the back, making a spiral movement in front of the shoulder; this is entrusted to an assistant. The outer end is then carried across the forearm, behind the back, over the opposite shoulder, and around the axilla. This meets the other end, which may be carried under the axilla and over the shoulder of the opposite side, thus making the figure-of-8 turn around the sound shoulder. This twist, it will be seen, makes also the figure-of-8 turn around the elbow of the affected side." The forearm is to be supported, with the elbow acutely flexed, by means of a sling. Hale³ has modified this dressing by the addition of an adjustable back-sling, to be tightened during the day, and loosened at night.

What is known as Sayre's apparatus⁴ consists of two broad bands of adhesive plaster; one surrounds the upper part of the arm of the injured side, and thence runs across the back and round the thorax; the second, beginning in front of the sound shoulder, passes over it, and diagonally across the back to the opposite elbow, thence up again, embracing the whole forearm and hand, to be fastened at or near the point of starting. A longitudinal slit

¹ Am. Journal of the Medical Sciences, Jan. 1856.

² Transactions of the Medical Society of the State of New York, 1870.

³ Medical Record, May 27, 1882.

⁴ Bellevue and Charity Hospital Reports, 1870.

in this strip receives the elbow, which is to be drawn well forward and inward.

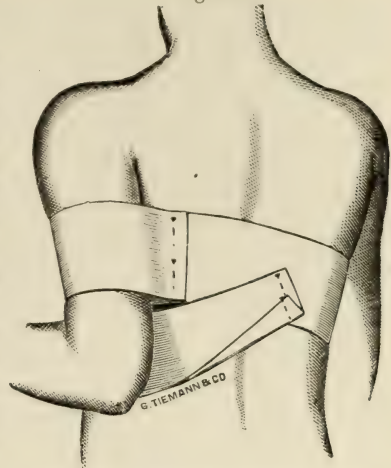
Satterthwaite¹ has proposed the substitution of the rubber bandage for adhesive plaster, and the use of a horseshoe-shaped dilatable bag, to be filled with water, as an axillary pad. The exact advantages to be derived from this change do not clearly appear, and the risk of excoriation would seem to be increased.

Hamilton describes his own method as follows:—²

“The arm hanging perpendicularly beside the body, a sling is placed under the elbow and forearm, and tied over the opposite shoulder. An axillary pad, composed of cotton batting inclosed in a cloth cover, is placed well up in the axilla, and the elbow is then secured firmly to the side of the body with several turns of a roller.”

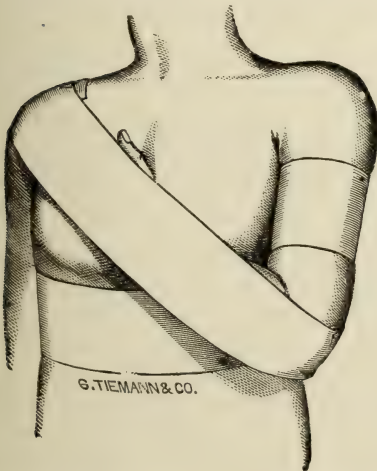
In addition to the somewhat numerous American devices already spoken of, I may merely mention those of Brown,³ Chisolm,⁴ Palmer,⁵ and Bradner;⁶ all of these have the advantage of simplicity, and it is claimed by their inventors that good results have been obtained by their use.

Fig. 823.



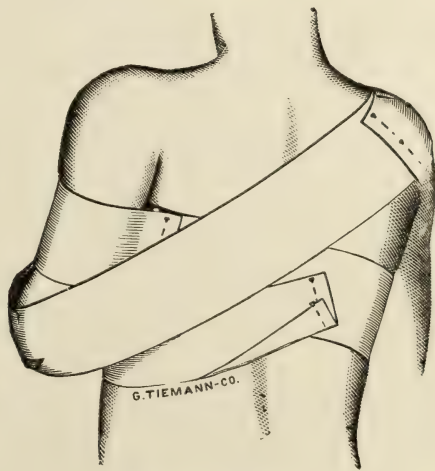
Dr. Sayre's dressing for fractured clavicle ;
application of first strip.

Fig. 824.



Dr. Sayre's dressing for fractured clavicle completed.
Front view.

Fig. 825.



The same. Back view.

Professor Gordon, of Belfast, the agreement of whose views with my own has been before mentioned, describes an apparatus of his own devising, consisting of a breast-plate and arm-splint, connected by means of a rod—the idea being to substitute the broken bone by this rod. Without questioning the theoretical value of this contrivance, or the statements of Professor Gordon

¹ Medical Record, September 27, 1879.

² Op. cit., 6th ed., p. 218.

³ Am. Medical Recorder, Oct. 1821.

⁴ Charleston Medical Journal, March, 1858.

⁵ Am. Journal of the Med. Sciences, July, 1863.

⁶ Medical Record, June 17, 1882.

as to the results obtained with it by him, I think that its complexity, and the fact that it can only be made by a skilled mechanic, will preclude its adoption, and, to a very great extent, its trial by other surgeons.

Professor Byrd, of Baltimore, has published¹ an account of an apparatus successfully used by him, consisting of two padded plates which are applied over the scapulæ; these are connected by a flat steel bar, carrying a lever which arches over the shoulder, and which has at its anterior end another padded plate, to press the shoulder backward. The apparatus is adjustable by screws, and kept in place by straps and buckles.

O'Connor² has recently proposed the use of plaster of Paris, somewhat as in the Bavarian splint (see p. 55), so as to make a sort of mould of the shoulder, the fracture being first reduced.

By some surgeons, compresses are applied to the prominence of the outer end of the sternal fragment, with a view of forcing it back into place. And this may be done with advantage, provided the reduction has first been completely effected, if the projection still persists. If, however, the cause of the deformity is the pushing in of the inner end of the distal fragment behind the outer end of the sternal—as I believe it to be in the majority of cases—the pressure of a compress can only force back both fragments, and serious harm may result. I have certainly seen it productive of severe pain.

With the view of rendering the fragments immovable, it was proposed by Guérin (de Vannes) to fix the sound arm against the side by means of a body-bandage, and to apply a dextrinated bandage to the head and affected shoulder, the face being averted from the latter. He recommended along with this the use of Desault's apparatus, starched or dextrinated. It is not stated by Malgaigne that this plan was ever put into practice; but probably few patients would be willing to submit to such an encasement, which would involve extreme discomfort.

Malgaigne suggested "surrounding and confining the two fragments by two steel hooks, like the forceps of Museux; just as in the serrated fracture with an angle upward, I thought," he says, "of passing in at the summit of the angle a double hook, which by means of a strap and band could be drawn toward the elbow, thus exerting all the necessary pressure." But he very justly remarks that the idea needs maturing; and I do not know that he ever followed it out any further.

Modern surgery has more than equalled the hardihood of Malgaigne. Langenbuch is reported³ to have treated a fracture of the clavicle by cutting down upon it, and suturing the fragments together with silver wire, the periosteum being also sewed with catgut. A very just criticism of this procedure has been published⁴ by Dawson, who maintains that the results obtained by ordinary means are sufficiently satisfactory to forbid running the risk involved in making the fracture compound, especially in the neighborhood of such important and vulnerable structures.

There are instances, however, in which an operation is entirely proper. Whitson⁵ reports the case of a boy, aged fifteen, who was knocked down and run over by a reaping-machine, sustaining a compound fracture of the right clavicle, and a compound fracture of the right humerus. On the sixth day, a thick wire suture was passed through the fragments of the former bone, and good union was obtained.

When, as in the last mentioned case, fracture of the clavicle is complicated by fractures of the neighboring bones, the treatment may be variously modi-

¹ Medical News, October 21, 1882.

² Medical News, Feb. 25, 1882.

³ British Med. Journal, Jan. 6, 1883.

⁴ British Med. Journal, March 3, 1883.

⁵ Medical Record, May 20, 1882.

fied. Thus Schneek¹ reports an instance in which a little girl five years of age sustained, by the kick of a colt, a fracture of the clavicle near its middle, and of the humerus near the shoulder. Fox's apparatus was applied, and a hollowed wooden splint along the outer side of the arm, with a girth surrounding this and the child's body. The clavicle was united in two weeks, and the humerus in four, without perceptible shortening or deformity.

Having now passed in brief review the principal plans which have been proposed or employed in the treatment of fractures of the clavicle, it remains for me to sum up the subject by a few practical directions. And in the first place I would say that the secret of success lies not so much in the employment of any special method of treatment, as in the recognition of the conditions to be met in each case, and in the adoption of means suited to them—in tact, judgment, and, above all, in careful attention. All fractures of the clavicle are not alike, nor can they all be treated in one way.

When there is much inflammation about the shoulder, as occasionally happens in fractures due to direct violence, the patient should be laid flat on the back, on a firm mattress, with his head low; and local applications, such as dilute lead-water and laudanum, evaporating lotions, or simple fomentations of hot water, should be employed for a few days.

After the inflammation has subsided, if there remain any malposition of the fragments, it should be carefully rectified as far as possible; and to maintain reduction, I think Sayre's plan will be found the most efficient means; but excellent results may be had with either Fox's or Levis's apparatus. Whichever is used must be carefully adapted to the exact requirements of each case. The forcing the elbow forward, so much insisted on by some authors a few years since, is in my opinion a mistake.

Should compresses be required to push back the sternal fragment, I would recommend the use of a well-padded ring, neither too large nor too small, maintained accurately in place by means of the best procurable adhesive plaster.

When an axillary pad is used, it should not be too thick, nor too strongly forced up into the armpit, lest undue pressure be made upon the large nerves. Hamilton mentions a number of instances in which harm was thus done.

Having had no experience in any of the grave complications of fracture of the clavicle, I shall not discuss their treatment. Non-union would seem to be productive in most cases of so little inconvenience, that a resort to operative measures need seldom be had; although the bone is so superficial as to be easily reached, and, if the cervical fascia be not torn, there will be but little risk of deep-seated inflammation.

Fracture of both clavicles would seem to me to be best treated by keeping the patient flat on his back, with an arrangement on the principle of a double truss, to keep the shoulders pressed gently backward. Of course the upper extremities should be kept at the most perfect rest.

FRACTURES OF THE SCAPULA.

The scapula is not often broken, partly by reason of its mobility, and partly because of the degree of protection afforded to its flat portions by the layers of muscle in which it is imbedded, while its spine, its neck, and the coracoid process, are but little exposed to violence. Of the recorded instances, the great majority were in male adults; about one in five were in women. Among the 316 cases of fracture before mentioned as treated at the Chil-

¹ Am. Journal of the Med. Sciences, April, 1858.

dren's Hospital in Philadelphia in seven years, the scapula was affected in only three.

In by far the greater number of cases, fractures of the scapula are due to direct violence. There was a man in my wards at the Episcopal Hospital in 1882, who, while working in a dye-house, had been jammed in a narrow space under a roller weighing 500 pounds, by which the body of the right shoulder blade was broken across. Many years ago I saw a railroad laborer who had had the bone comminuted by a blow from the rapidly revolving crank of a hand-car. A not unfrequent cause is a fall from a height, the patient striking on the back and shoulders.

Muscular action has been assigned as the cause of fracture of the scapula in two cases. One of these, quoted by Callaway,¹ as observed by Dr. Heylen, is given in detail, and admits of no doubt; the patient, a man of 49, hung by one hand to a cart while the horse ran a distance of about one hundred yards; the diagnosis of fracture was clear, and there was no bruise or other indication of a blow on the part. The other case is very briefly reported by Mr. M. Morris;² it was that of a locomotive engineer, who was making some exertion, and fell forward, striking his chest against the lever; he felt at the same time a crack in his shoulder, and the scapula was found to have been broken. The fracture is said to have been through the spine, about an inch from the triangular surface over which the trapezius plays. Union took place, but a ridge was left at the seat of injury.

Fracture may occur at different portions of this bone. Fig. 826 shows a not unfrequent form, the spine and the body of the bone being affected. As

Fig. 826.



Fracture of the scapula.

in the case of other flat bones, fissures are often seen in connection with complete fractures. No instance is on record of a fracture involving the spine alone, although the *acromion process* has occasionally been broken off, either by a blow from above, or by the humerus being forcibly driven upward. The *lower angle* of the bone is sometimes separated. When the line of breakage is higher up, it is apt to be more irregular, and the bone may be comminuted. Callaway gives a representation of a fracture produced by the fall of a mass of slate on the patient; one line runs across the bone just below the base of the spine, terminating at the root of the coracoid process, which is broken off; another runs off from near the mid-point of this line, downward and outward to a point perhaps an inch from the lower margin of the glenoid cavity. The bone is thus broken into

four pieces: one comprising the upper angle, the spine, and a strip of the body; a second, the lower angle with part of the body; a third, the glenoid cavity, neck, and part of the body; and, lastly, the coracoid process.

A few instances are upon record in which the *coracoid process* has itself been broken off. One such occurred under my own observation many years since, in the person of an elderly woman, who fell backward in a narrow passage, striking on her elbow, and thus forcing the head of the humerus upward and forward.

¹ A Dissertation upon Dislocations and Fractures of the Clavicle and Shoulder Joint. London, 1849.

² British Med. Journal, Sept. 16, 1876.

Fractures of the *neck* of the scapula have been by some authors regarded as of more common occurrence than they really are. In fact, the neck of the scapula as described by anatomists—the constricted part of the bone close to the glenoid cavity—has never been found fractured upon dissection. A few cases, however, have been studied, and among them one reported, and the specimen figured, by Callaway,¹ in which the line of breakage has run from some point in the upper margin of the bone, so as to include the supra-scapular notch and coracoid process, downward and outward to some point in the outer margin, more or less close to the glenoid cavity.

Upon an examination of a normal scapula, it will be found that such a line of separation, running as in Callaway's case for example, first downward and then outward, would surround a portion of the bone which constitutes really its thickest part. A portion of the root of the spine is included in it. By Gurlt and others it is proposed to call this the "surgical neck" of the scapula, while to the narrowed portion just around the glenoid cavity is given the name "anatomical neck." The extreme improbability of a fracture through this last-named part will be obvious at once to any one who looks at a vertical section displaying the arrangement of the bony texture, and who considers the relations it bears to surrounding parts; the former being such as to diffuse as much as possible any stress brought to bear upon the bone, in any way whatever, and the latter being such as to render its fixation, so that a "cross-breaking strain" could be exerted upon it, impossible.

I think, therefore, that it may be asserted that the neck of the scapula, surgically speaking, corresponds to the line above mentioned; and that when fracture occurs in this part of the bone, it follows very nearly the direction thus marked out. With this view clinical facts are entirely in accord.

In order to arrive at a clear understanding of the mechanism of the displacement in fractures of the scapula, the attachment of the muscles to it must be carefully studied. Let it be remembered that this bone finds its sole direct connection with the thorax through its articulation with the clavicle. Apart from this, it is merely supported by muscles.

When fracture takes place across the flat part below the spine, the lower fragment tends to ride up, either in front of the upper or behind it, according to the action of the fracturing force; and this tendency is favored by the contraction of the rhomboidei and teres major; the latter aided by some, at least, of the fibres of the serratus magnus. A number of museum specimens which I have examined, as well as several figured by Gurlt, and two by Malgaigne, illustrate this. In one case, recorded by Easley,² where a longitudinal fracture of the body was caused by great violence, the patient having been run over by a wagon the wheel of which passed lengthwise over the scapula, the displacement from muscular action was very marked.

When the upper angle is broken off, the tilting action of the levator anguli scapulæ is quite distinct, as in a bone represented by Gurlt;³ a gap is even left at the posterior edge between the fragments.

When the fracture affects the body and spine, as in the case seen by me, from which Fig. 826 was taken, the fragments may be so nearly balanced by the contraction of opposing muscles, as to be in reality very slightly disturbed in their relations to one another.

In the cases of fracture of the *neck* of the bone, it appears that there is sometimes very little displacement. Thus, in an instance reported by Ashhurst,⁴ in a boy five years old, the diagnosis could only be made by exclusion.

¹ Op. cit., p. 93. Plate I. fig. 1.

² Am. Journal of the Med. Sciences, Jan. 1878.

³ Op. cit., Bd. ii. S. 528, Fig. 45.

⁴ Trans. of Coll. of Phys. of Philadelphia, 3d s. vol. i. 1875.

This may be explained in great measure by the fact that the fragment is supported by the coraco-clavicular and coraco-acromial ligaments, as well as to some extent by the long head of the biceps. But the tendency is for the fragment to be merely tilted downward by the action of the coraco-brachialis, the short head of the biceps, and the middle head of the triceps; with the result of somewhat flattening the shoulder, and thus producing an appearance at first sight simulating downward luxation of the head of the humerus.

This fracture may be, as in the case quoted by Gurlt from Duverney, complicated by fractures of the ribs; and from the violence requisite to cause it, other bones also in the neighborhood are apt to suffer.

Fracture of the *glenoid cavity* has been, in most of the recorded cases, observed in connection with luxation of the shoulder, the latter being the lesion seemingly of most importance. But in one instance, reported by Assaky¹ to the Société Anatomique, the history is given as follows: "A man, aged 65, got a fall, striking his shoulder against a beam lying on the ground; he was taken to the Hôpital de la Charité, where the interne thought he detected and reduced a subcoracoid luxation. About a month afterward the man died of pleuro-pneumonia; and at the autopsy there was found a stellated fracture of the glenoid cavity, the fissures, three in number, extending back into the substance of the neck of the bone, where union had occurred with superabundant callus, composed of fibrous tissue with osseous deposits. A fracture of the acromion also existed, at which suppuration had taken place; there were some irregular bony deposits in the neighborhood."

The *diagnosis* of these fractures has been incidentally referred to in connection with their symptoms. It is generally not difficult to determine the fact of the bone being broken, by the tenderness on pressure, the loss of certain motions of the upper arm—especially those upward and backward, the abnormal mobility of the bone when grasped above and below, the detection of distinct irregularities of outline, and the crepitus elicited, especially by rotating the arm. But to make out the precise line or lines of separation is a matter of far more difficulty. I had in my ward at the Episcopal Hospital, in 1882, a man who had had a heavy beam fall on his shoulder, in whom a fracture could be plainly felt at the posterior edge of the scapula, but it could not be traced any further forward.

Fracture of the *neck* of the bone is distinguished from luxation by the facts that the humerus is freely movable in every direction; that the hand can be placed on the opposite shoulder, the elbow being kept at the side; that the displacement is readily corrected, but as readily reproduced; and that crepitus is present. The analogy between these cases and those of double vertical fracture of the pelvis is very marked.

When the *coracoid process* alone is broken, the fragment can be grasped and felt to be movable upon the rest of the bone; the crepitus, if perceived, gives the sensation of smallness of the surfaces in contact; and the action of the biceps and coraco-brachialis muscles is lost. Hamilton cites a number of instances in which the diagnosis was clearly established, both by himself and by others; and dissections have been made, which set beyond a doubt the fact that this fracture may occur. Yet very careful examination is requisite before it can be asserted to exist in any case.

Fracture of the *acromion*, when it takes place, is not difficult of detection, by means simply of the pain, tenderness on handling, loss of power (from pain), mobility, and crepitus. Many of the museum specimens, which are

¹ Le Progrès Médical, 11 Fév. 1882.

supposed to exhibit non-union after fracture of this process, are in fact merely examples of want of consolidation of the epiphysis.

In regard to *prognosis*, it may be said that fractures of the scapula in general unite readily, and often without perceptible displacement; and that the functions of the arm are seldom permanently impaired.

Very little can be done in the way of *treatment* of these injuries. The arm should be supported with a sling, in such a position as in each case may be found best adapted to obviate whatever displacement exists; and the shoulder should be confined by adhesive plaster applied so as to steady and control the fragments. In fractures of the neck of the bone, an axillary pad may be of service; but it should not be too large, lest it should aggravate, by pressure on the muscles, the very condition it is intended to relieve.

FRACTURES OF THE HUMERUS.

These injuries are by no means infrequent, but the testimony of those authors who have offered statistics on the subject is not uniform; and it is probable that the experience of different surgeons, or the records of different hospitals, would be found, as in other matters, to vary somewhat. Thus Gurlt, quoting those of the London hospitals, says that out of 22,616 fractures treated during twenty years, there were 1651, or 7.3 per cent. affecting the humerus. But Malgaigne, among 2358 fractures observed at the Hôtel Dieu, found 317 of the humerus—over 13 per cent.; and of the 316 cases derived by me from reports of the Children's Hospital in Philadelphia for seven years, there were 72, or about 22.6 per cent. I do not, however, propose to dwell upon these statistical points, and mention them merely in illustration of the difficulty of arriving at conclusions in regard to questions of this kind.

Very marked differences exist between different portions of the humerus in their liability to fracture; but before discussing these, the anatomy of the bone must be briefly sketched.

The *head* of the humerus, nearly hemispherical, looks upward, inward, and slightly backward; a very shallow constriction at its circumference, made apparently deeper by the prominence of the greater and lesser tuberosities, is called the *anatomical neck*. Just below this, beginning at the upper margin of the *tuberosities*, and extending to the insertion of the *teres major* muscle, is the *surgical neck*; the tapering of this portion of the bone from above downward should be specially noted. Below this is the *shaft*; cylindrical above, and flattening out at its lower part, it widens greatly towards the elbow. The lower end of the bone is turned somewhat forward, and presents the pulley-like surface on which the ulna plays, with a rounded eminence at the outer side of this for the head of the radius. Above the *trochlea*, at the inner margin of the bone, projects the process called the *internal condyle* or *epitrochlea*, and corresponding to it on the outer margin is a smaller prominence, the *outer condyle*, sometimes called the *epicondyle*.

The upper epiphysis of the humerus, which unites with the shaft at about the twentieth year of life, is somewhat dome or cap-shaped, and comprises the head and tuberosities, developing from two centres. The lower epiphysis, having four centres, comprises the portion below the sigmoid cavity, and corresponds quite closely in extent with the articulating portion of the bone, although the epicondyles, internal and external, are on a slightly higher level on either side.

A thorough familiarity with the muscular attachments afforded by the humerus, will enable the student of the fractures of this bone to comprehend much more readily the mechanism of their production, as well as of the resulting displacement. This matter will be further referred to in connection with the fractures of different portions of the bone.

Fractures of the humerus may be divided roughly, and for general purposes, into those of the upper end, those of the shaft, and those of the lower end. Under each of these heads are comprised several varieties, distinct in their anatomical and clinical features. But before entering upon the discussion of these, I would call attention to the curious statistics presented by Gurlt¹ as to the influence of age and sex upon their relative frequency. Of 194 cases of fracture of the humerus, there were—

Between	1 and 10 years of age,	62 cases, or over	31 per cent.
"	11 " 20	" 42 "	" 21 "
"	21 " 30	" 22 "	" 11 "
"	31 " 40	" 16 "	nearly 9 "
"	41 " 50	" 9 "	" 5 "
"	51 " 60	" 22 "	over 11 "
"	61 " 70	" 16 "	nearly 9 "
"	71 " 80	" 5 "	" 3 "

Malgaigne's statistics present a different view. He says that of 310 cases of simple fracture of the humerus, there were—

From	2 to 20 years of age,	45 cases, or over	14 per cent.
"	20 " 40	" 80 "	" 25 "
"	40 " 60	" 105 "	" 33 "
"	60 " 80 and over	" 80 "	" 25 "

The remarkable discrepancy between these two sets of figures must be at once apparent, but I confess that no explanation of it occurs to me.

Now as to the relative frequency of fractures of the various portions of the bone at different ages, Gurlt gives the following:—

Age.	Upper end.	Shaft.	Lower end.
Between 1 and 10	4 = over 6 per cent. ²	14 = over 22 per cent.	44 = 70 per cent.
" 11 " 20	11 = " 26 "	10 = 25 "	21 = 50 "
" 21 " 30	3 = " 13 "	13 = 59 "	6 = over 27 "
" 31 " 40	3 = " 18 "	5 = over 31 "	8 = 50 "
" 41 " 50	6 = " 66 "	2 = " 22 "	1 = 11 "
" 51 " 60	11 = " 50 "	9 = " 40 "	2 = 9 "
" 61 " 70	8 = " 50 "	7 = nearly 44 "	1 = over 6 "
" 71 " 80	2 = " 40 "	2 = 40 "	1 = 20 "
	48	62	84
			194

The reader will scarcely fail to observe the great preponderance of fractures at the lower end of the humerus in the first two decades of life, and the increase of those of the upper end of the bone between the ages of 51 and 60—the time when, although active pursuits are not yet abandoned, the ability to avoid falls is diminished.

As to the influence of sex, I will merely say that the males are very largely in excess of the females in every portion of Gurlt's table except four; in the first decade of life the fractures of the shaft, and between 71 and 80 years those of the upper end as well as of the shaft, show equal numbers for the two

¹ Op. cit., Bd. ii. S. 653.

² It should be noted that the percentages in the above table refer to the totals for the different ages, given in the first table quoted from Gurlt.

sexes, while in the latter period the only fracture of the lower end of the bone was in a female.

FRACTURES OF THE UPPER END OF THE HUMERUS.—Fractures of the upper portion of the humerus include those of the head, of the anatomical neck, of the tuberosities (the greater being the only one clearly made out to have been broken off), and of the surgical neck. Under the last head are embraced separations of the upper epiphysis.

Fracture of the *head of the humerus* by itself is certainly very rare. Dorsey¹ speaks of one case seen by him in which the lesion was "within the capsular ligament, the fracture extending through the head of the bone." Gross² says that he has seen "an instance of the kind, which had been mistaken by the attendants for a fracture of the acromion process, and the true nature of which was not detected until several years after the occurrence of the accident, when the man, who was upwards of forty years of age, died of disease of the liver. The fracture, as was shown on dissection, had extended obliquely from above downward through the head of the bone; and although it had become perfectly consolidated, there were several rough prominences which, while they unmistakably indicated the seat of the injury, had greatly impeded the movements of the shoulder-joint. The accident had been caused by a fall from a carriage."

Malgaigne records and figures several cases in which the head of the bone was more or less distinctly broken, but in connection with other injuries.

Our sources of information in regard to these lesions (and in fact in regard to very many injuries in the neighborhood of joints) are narrowed by the difficulty of accurate diagnosis. When the patients recover, the real character of the damage done must, of course, always remain open to some doubt. And even dissection, except in cases in which the fatal result has occurred soon after the hurt, may fail to clear the matter up, the condition of the parts being often such as might have resulted from disease, inflammatory or otherwise, altogether independent of fracture.

These fractures would seem to be always due to direct, crushing violence, the head of the bone being, perhaps, most frequently driven against the glenoid cavity, by a force acting in such a direction as to take it at a disadvantage.

A greater or less degree of arthritis of the shoulder must almost certainly ensue, with pain and swelling in the part, and loss of power in the limb. Displacement is not noted in any of the recorded cases, and, if it did occur, would be attributable to the fracturing force, since there is no muscular action which could cause it. Fraser³ reports a case which he regarded as fracture of the head of the humerus, complicated with a laceration of the axillary vein. The vessel was tied above and below the opening in it, and a portion of bone—exactly what part of the humerus is not clearly stated—was sawed off. A tedious convalescence ensued, but the ultimate result seems to have been excellent. Holmes⁴ mentions a case of fracture of the anatomical neck of the humerus, in which a subordinate line of fracture ran upward into the joint. There was partial rupture and obstruction of the axillary artery, leading to gangrene of the arm, and necessitating amputation at the shoulder-joint.

Fractures of the *anatomical neck of the humerus* are by no means uncommon. They are often spoken of as intracapsular, although it is likely that the line of

¹ Elements of Surgery, vol. i. p. 141.

² System of Surgery, 6th edition, vol. i. p. 980.

³ Lancet, July 8, 1848.

⁴ Principles and Practice of Surgery, Am. ed. p. 260.

separation seldom lies wholly within the joint. Elderly persons are the most frequent subjects of these injuries, the mechanism of which it is not easy to determine with certainty. My own belief is that a blow either on the front or back of the shoulder, or perhaps the forcing of the humerus upward against the acromion, may in many cases be assigned as the cause.

Very curious displacements of the fragment have been noted. Gross¹ records two: one in which the head of the bone was "turned upside down, the centre of the articulating surface corresponding with the outer border of the shaft," and the other in which the fragment was "tilted over the greater tuberosity against the posterior surface of the bone." Firm union had taken place in both.

R. W. Smith² gives some very singular instances: one in which the head of the bone was simply sunk deep into the cancellous structure of the other fragment, and two in which it had been so completely rotated as to have its rounded articular surface applied to the same part; he quotes a third case of the same kind as having been observed by Nélaton, and a fourth as recorded by Malgaigne.

Occasionally these fractures of the neck of the humerus are complicated by actual luxation of the head of the bone downward, or downward and forward. At least two of Smith's cases were of this character. Cock³ mentions a case treated by Poland, which was thought to be a dislocation into the axilla; but under chloroform a fracture was detected; the head of the bone could not be replaced; and the patient finally left the hospital with the arm shortened about two inches. He is said to have "regained considerable use of the limb." Dr. Fraser, of Michigan,⁴ reports a case in which a boy aged 15, being caught in some machinery, sustained, among other severe injuries, a fracture of the anatomical neck of the left humerus, with displacement downward of the head. It is simply stated that the luxation was reduced under chloroform, and that "perfect recovery" took place in forty-five days. Bennett⁵ reports five cases of dislocation of the humerus, complicated with fracture, beginning at the anatomical neck and passing obliquely into the shaft, detaching the lesser tuberosity along with the head. He suggests that the luxation occurs first, and that the fracture is produced by pressure against the edge of the glenoid cavity. This explanation is much more probable than that offered by Hutchinson,⁶ who thinks that the supposed cases of fracture with dislocation are really instances of fracture very high up, in which the head of the bone has gradually travelled downward to a new articular facet, by what mechanism does not appear.

A case recently occurred at the Pennsylvania Hospital, in a man of about seventy-six, who fell down stairs and sustained a fracture of the neck of the humerus, with displacement of the head of the bone into the axilla, where it gave so much trouble that Dr. Morton excised it; the result was satisfactory.

Fractures of the *greater tuberosity of the humerus* have been observed mainly in connection with other injuries, either fractures of the anatomical neck of the bone, the upper fragment having been forced down into the lower so as to split it, or luxations, in which stress must have been put upon the muscles attached to the process in question. In a few instances, however, the tuberosity has been separated by itself; and in three, according to Gurlt, the *lesser tuberosity* has been in like manner detached. It seems to me that these lesions may be appropriately classed with "sprain-fractures;" and I venture to refer

¹ Op. cit., vol. i. p. 981.

² Op. cit., pp. 187 *et seq.*

³ Guy's Hospital Reports, 3d s., vol. i.

⁴ Am. Journal of the Med. Sciences, April, 1869.

⁵ British Med. Journal, Aug. 28, 1880.

⁶ Med. Times and Gazette, March 10, 1866.

the reader to the very full discussion of them by Gurlt, merely remarking that the influence of muscular action is distinctly traceable in the displacement of the fragments in these cases. R. W. Smith¹ has recorded a case examined by him after death, in which the greater tuberosity, together with a very small portion of the outer part of the head of the bone, had been completely separated from the shaft of the humerus. This portion of the bone occupied the glenoid cavity, the head of the humerus having been drawn inward so as to project upon the inner side of the coracoid process; it was still, however, contained within the capsular ligament. Nothing was known of the history of the injury, which was of ancient date.

In all these cases of fracture occurring in the immediate neighborhood of the shoulder-joint, there is apt to be a very abundant deposit of new bone in irregular, stalactiform shapes, and this is one chief cause of the impaired freedom of motion which generally ensues upon such injuries. In this, as in many other respects, there is a very marked analogy between fractures in this region and those which affect the corresponding portion of the femur.

Along with the separation of the greater tuberosity, and in consequence of it, there is apt to be a displacement of the tendon constituting the long head of the biceps muscle. If the lesser tuberosity is also broken off, the tendon may slip forward and allow the head of the bone to be pushed outward; otherwise the subscapularis will tend to rotate the whole humerus inward, and thus add to the appearance of depression below the acromion, as well as to the increase in breadth of the shoulder.

Epiphyseal disjunctions are sometimes met with at the upper part of the humerus. About the fifth year of life, the head and tubercles become consolidated, and the mass thus formed unites with the shaft at or near the twentieth year. Examination of a vertical section of a young bone shows that the line marking the epiphysis begins at the axillary margin of the head, and runs across, rising slightly toward the centre, in a direction nearly horizontal, to terminate at the outer side just below the tuberosity. Hence it is evident that the epiphysis, like a cap, rests with its concavity upon the convex end of the shaft.

Below this the bone tapers somewhat decidedly; and, as before said, the *surgical neck of the humerus*, in the adult bone, comprises all between the upper part of the tuberosities and the insertion of the *teres major*, the lower boundary being but ill-defined.

Fractures of this part have so much in common with epiphyseal separations, that I have thought it best to discuss them together, merely pointing out the clinical differences existing between the two.

Bouchut mentions that Foucher saw, in a girl aged 13, the upper epiphysis of the humerus separated by muscular action, in taking a frame down from a wall above her head. An abscess formed, and death ensued in about seven weeks, when the diagnosis was verified by an autopsy. Hutchinson² mentions a case in which, by a fall from a mast, both the upper and lower epiphyses of the humerus were detached. A somewhat similar case is reported by Macnaughton Jones;³ a double fracture of the humerus, near the neck and near the elbow, with separation of a longitudinal fragment from either extremity of the shaft.

All fractures of the humerus between the tuberosities and the shaft proper of the bone, present the peculiarity, that there is a short upper fragment, acted upon by strong muscles, the *supra-spinatus*, *infra-spinatus*, *subscapularis*, and *teres minor*, the effect of which is to roll the head of the humerus over

¹ Op. cit., p. 178.

² Med. Times and Gazette, March 10, 1866.

³ British Med. Journal, Dec. 24, 1881.

inward, and thus to tilt up the lower end of the upper fragment, so that its fractured surface tends to look outward. The lower fragment is at the same time drawn inward by the muscles attached to its upper end, while it is pulled upward by the deltoid, biceps (short head), coraco-brachialis, and scapular head of the triceps. Hence, the moment that there is any engagement of the two fragments in their changed relation, the tendency of the muscles is to keep up, and even to increase, the disturbance of the upper fragment.

The line of separation in epiphyseal disjunctions has already been spoken of; in fractures through the surgical neck, I think it is, as a general rule, from without inward and downward, or nearly parallel with the plane of the anatomical neck—a circumstance which tends to lessen the degree of the deformity, since the long point of the upper fragment within, and that of the lower fragment without, are in the way each of the other's displacement. When, however, there is an obliquity also from before backward, or from behind forward, the upper fragment may be so tilted as to point outward.

Of this form of displacement one notable example exists in the Mütter Museum, in a specimen of epiphyseal disjunction, the lower fragment overlapping the other inwardly, and in close contact with it, while the latter is so tilted by the action of the scapular muscles, that a space, filled up, however, by callus, is left between the two fragments at the outer part of the fracture.

This is by no means an isolated instance. In the majority of the specimens figured by Sir A. Cooper, Malgaigne, Gurlt, and other authors, and notably in one illustration first given by Moore, and borrowed by Hamilton and others, the same mechanism is clearly traceable; and this evidence is the stronger, in that it is altogether unintentional on the part of those presenting it. Malgaigne, indeed, says: "The upper fragment is in a position answering to the greatest elevation of the arm in its normal state."

A striking illustration of this tilting action once came under my notice in a case of railroad injury, the humerus being crushed to within a few inches of the shoulder. While the patient was being etherized preparatory to the removal of the limb, the point of the upper fragment was repeatedly thrust strongly against the inner surface of the deltoid by the muscles mentioned.

Further confirmation of this view is afforded by the fact that in most cases of fracture in this region there is, after recovery, a limitation of the movement of the arm directly upward, by reason of the approximation of the points of insertion of the scapular muscles to their origins.

Sometimes, along with fractures in this region, the head of the bone becomes dislodged from the axilla. Hingeston's case,¹ in which the neck of the bone was broken into six pieces, which became united again, is a very remarkable one. Dr. J. Watson² reports two cases, in both of which the cause of injury was direct violence; in one the fracture was through the surgical neck(?) "midway between the upper end of the bone and the insertion of the deltoid," and in the other "near the tubercles." Reduction was effected immediately in both, without splinting the limb; in the latter case the arm was drawn out at right angles with the body, and the head of the bone coaxed into the glenoid cavity by manipulation with the fingers. Richet³ has placed on record a case of fracture of the surgical neck of the left humerus, with luxation of the head of the bone into the axilla. Reduction was effected by manipulation with the fingers, a few days after the accident, and ultimately the shape and usefulness of the limb were entirely regained. Norris⁴ reports a case

¹ Guy's Hospital Reports, 1st S., vol. v., 1840.

² New York Medical Times, July, 1854.

³ Quoted in Am. Journal of the Med. Sciences, April, 1854.

⁴ Am. Journal of the Med. Sciences, Jan., 1855, and Summary of Transactions of College of Physicians of Philadelphia, N. S., vol. ii. No. 6.

under his care, which had been treated for fracture for twenty-six days, when it was discovered that the head of the humerus was in the axilla. No effort was made at reduction. One other case, which had occurred in the Pennsylvania Hospital, reported by Hartshorne, is referred to, as well as others recorded by Houzelot, Dupuytren, Earle, Peyrani, and A. Cooper. Walton¹ has reported the case of a man, aged 48, in whom a fracture of the neck of the humerus was treated, but a dislocation downward was not recognized for ten weeks. Union of the fracture had then occurred, but the displaced head of the bone gave great pain. The reduction was effected by extension continued for three-quarters of an hour, the whole arm being very carefully and firmly put up in splints beforehand. "A good deal of local and general disturbance followed, but at the end of three weeks passive motion was commenced, and at the end of six weeks the arm could be used nearly as well as the other."

The *symptoms* of separation of the upper epiphysis of the humerus are often somewhat obscure. There is pain and loss of power, with some swelling; and a rather rough ridge is apt to be felt across the front of the joint, at which crepitus is more or less distinctly felt on rotating the arm. In the few cases which I have seen the ridge has been less prominent than it is represented by R. W. Smith in his work; it is due to the projection forward of the edge of the lower fragment. The degree of mobility is not great, and the crepitus conveys an idea of smoothness of the surfaces in contact as compared with those of an ordinary fracture. In making the diagnosis, the age of the patient is an important point to be considered.

Fractures of the surgical neck of the bone are, as a general rule, easily recognized; besides total loss of power in the limb, free preternatural mobility, and distinct crepitus, the exact line of the fracture can often be made out by feeling. Sir A. Cooper has represented² a double fracture in this region, but gives no history of the case. Such an injury, probably due to great direct violence, would not be likely to offer any special difficulty in diagnosis, unless the swelling of the soft parts were excessive.

Fractures of the upper portion of the humerus for the most part unite readily, with the exception of those in which there is displacement of the head of the bone from the glenoid cavity. Even when the change of relation between the fragments is most marked, as in the instances before quoted from Gross and R. W. Smith, consolidation seems to have occurred in every instance. And, as a rule, the usefulness of the limb is in great measure regained, although the mobility of the shoulder-joint is of necessity impaired, either as a result of inflammation, or by the change of the points of attachment of the muscles, or by the substitution of some portion of one or other fragment for the head of the bone, in contact with the glenoid cavity.

Non-union is, however, occasionally met with, as in a case recently reported:³ A girl, aged twenty, had the surgical neck of the right humerus fractured three times, twice by direct violence, and the third time by the stress put upon it in drawing on a tight boot; the fragments remaining ununited, "Mr. Croly cut down on the fracture under the spray, drilled the ends of the bones, and wired them. The case was not a favorable one for the operation, inasmuch as the periosteum was separated to a considerable extent, and the ends of the bones were widely apart. Necrosis setting in, and extensive suppuration and hectic threatening the patient's life, amputation was decided on." The patient was doing well at the time of the report.

¹ Lancet, Oct. 30, 1868.

² Treatise on Dislocations and Fractures of the Joints, p. 433. London, 1842.

³ British Med. Journal, March 17, 1883.

Compound fractures of the upper third of the humerus are extremely rare, except as the effect of gunshot injury. They are always of grave importance, and may demand excision, or even amputation.

Skey¹ met with a case in which a dislocation of the humerus was reduced; eight or ten days afterwards, a large traumatic aneurism was developed in the axilla, and the artery was tied above and below. After the patient's death, it was found that he had had "a fracture of the neck of the humerus," and that the artery had been "torn across" by the pointed end of the shaft.

In the Museum of St. Bartholomew's Hospital² there is a specimen of ununited fracture of the neck of the humerus, with obliteration of the axillary artery by pressure of the lower fragment of the bone against it. The subject, a man aged 75, had received the injury ten years previous to his death.

"The fracture extends transversely through the humerus, immediately below its head and below the tuberosities; and it communicates with the cavity of the shoulder-joint. A small detached piece of the bone is connected with the synovial membrane. The synovial membrane is thickened, and its internal surface is rough. The axillary artery is obliterated to the extent of half an inch, in the situation in which the end of the lower portion of the bone pressed against it. Immediately above the obliterated part, the infra-scapular artery arises, of its usual size, and pervious. Close to the infra-scapular is the posterior circumflex artery, obliterated in the first half inch from its origin, and then pervious by means of the collateral circulation. About two inches above the origin of the infra-scapular, a large branch arises from the axillary artery; this branch, extending down inside of the arm, was continued into one of the arteries of the forearm, and formed a principal channel for transmitting blood to the lower part of the limb."

The nerves are very rarely injured. One such case is recorded by Berger,³ in which the musculo-spiral nerve was pressed upon, and paralysis of the parts supplied by it resulted, with some superficial sloughs. The patient, a man, died of malignant scarlet fever.

Treatment of Fractures of the Upper Part of the Humerus.—In fractures near the upper end of the humerus, the proximity of the shoulder-joint, and the danger of its stiffening, should always be borne in mind. When there is much swelling and inflammation, the most prompt and efficient means should be employed to allay it; the patient should be kept at rest in bed, with the arm and hand on a pillow, and hot fomentations should be constantly used. Where the injury has been caused by great direct violence, it may be well even to apply leeches to the part. On the subsidence of the inflammation, the condition of the fragments should be very carefully ascertained, and measures adopted for correcting any displacement that may exist. If this be very slight, as may happen in feeble persons, or when the periosteum is not wholly torn through, the suspension of the arm in a sling, with a small and soft axillary pad, may suffice; or the arm may be confined to the side by a bandage applied around it and the body, the hand merely being placed in a sling.

Some surgeons employ a splint along the inner side of the arm, with a leather or pasteboard cap fitted on the shoulder, the whole being kept in place by a bandage, a few turns of which are carried around the chest.

But in very many instances, in which the upper fragment is tilted inward by the scapular muscles, as before explained, it affords so little purchase that the only efficient method of correcting the displacement is to carry the lower fragment upward, which is best done by putting an angular splint in the

¹ Lancet, May 5, 1860.

² Catalogue, vol i. p. 32.

³ Bulletin de la Soc. Anatomique, Juillet, 1871.

axilla, so that one branch of it shall be applied to the side of the chest, and the other along the inner side of the arm. This splint, well padded, may be secured by a bandage, which in the case of very restless patients may be imbued with plaster of Paris or some other solidifying material. Such a splint was long ago recommended by Tyrrell, and has been more recently employed by Middeldorpf, Gély, and others. It is not needful to retain the arm in this position during the whole period of repair, but only for the first two or three weeks, after which a gradual lowering of the elbow may be effected without putting too much stress upon the newly-formed uniting material.

When this splint is used, the binder's board shoulder-cap may be dispensed with. In any case, the cap need extend no further over the shoulder than just to cover in the acromio-clavicular junction. I recently had a woman, aged 57, in my ward at the Episcopal Hospital, who had sustained a fracture of the surgical neck of the left humerus, and in whom the upper fragment projected into the axilla, while the lower was drawn up so as to overlap it at its outer side. I succeeded in overcoming this deformity by means of gentle pressure with a small, firm compress, held in place by a wide strip of adhesive plaster carried around the arm and up upon the shoulder (Fig. 827), the hand being, of course, supported in a sling. The ultimate result of the case I do not know.

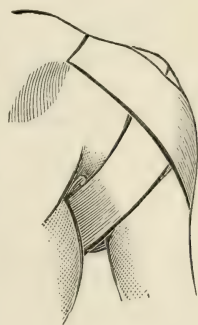
Fractures of the tuberosities admit of very little in the way of treatment, as the purchase afforded by the separated portions is so slight. The elbow, however, should be supported, and the arm placed and kept in such a position as may be found to correct the deformity most completely.

When, along with fracture, there is dislocation of the head of the bone from the glenoid cavity, it becomes a question whether the dislocation or the fracture should be first treated. Cases might be cited in favor of either course; but it seems to me that, as a general rule, an effort at immediate reduction of the head of the bone ought to be made. Such a procedure is certainly difficult; but, on the other hand, the fragments can scarcely be brought into proper relation as long as the head of the bone remains out of the glenoid cavity, and the reduction cannot be easy if put off until after the occurrence of union. Indeed, from the cases quoted on a previous page, it must be evident that a change in the position of the head of the bone is very apt to occur even when there is no luxation. Should the reduction be found impossible, the shaft should be placed in the best attainable position for union between it and the head, in hope that after four or five weeks the attempt may be renewed, with the advantage of the leverage afforded by the length of the bone; although there may be adhesions, changes in the capsule, etc., as in other cases of old luxation, which may foil the best directed efforts. Hence, it must be evident that the prospect in cases of this kind is anything but encouraging.

When, reduction being impracticable, the displaced head gives rise to serious trouble, the proper course is to excise it.

FRACTURE OF THE SHAFT OF THE HUMERUS is of very frequent occurrence, and is met with at all ages and in both sexes. An instance is reported by Löwenhardt¹ in which a fracture of the upper third of the left humerus took place

Fig. 827.



Application of compress and adhesive plaster to overcome deformity in fracture of the surgical neck of the humerus.

¹ Am. Journal of the Med. Sciences, Jan. 1841; originally in *Medizinische Zeitung*, 6 Mai, 1840.

during the expulsion of a child from the mother's pelvis, the arm lying across the chest; and Hamilton mentions a similar case as having been seen by him, which had occurred in the practice of a Dr. Lockwood, as well as another related to him by Dr. Fanning, of Catskill, N. Y. The latter case was one of head-presentation, and, as the right shoulder passed under the arch of the pubis, a snap was heard, the humerus giving way in its upper third. From Gurlt's table, before quoted, it would seem that females are very much more liable to this injury during the first decade of life than in any subsequent one, while it is most common in males between the twentieth and thirtieth years. Under ten years, the cases in males and females are equally numerous, as they are also after the seventieth year; but in the intermediate period the cases in males are largely in excess. These statements, it must be remembered, are based upon a comparatively small number of cases; but they are sufficiently in accord with ordinary experience to be accepted, although further observation may modify them to some extent.

Under the term "shaft of the humerus," is comprised all of the bone between the lower limit of the surgical neck and the abrupt widening just above the condyles. Every variety of fracture may occur in the region thus included, and from every variety of cause—direct or indirect violence, or muscular action. Fractures from the last-named cause are, indeed, more frequently met with in the humerus than in any other bone in the body.

A thorough knowledge of the muscular connections of the humerus is essential to a proper understanding of the mechanism of the production of these lesions, as well as of the displacements which ensue upon fractures from whatever cause.

The upper extremity constitutes a mechanical system, of which the clavicle and scapula form a part, and in which the humerus is an intermediate lever; the ultimate object of the whole being the discharge of the functions of the hand. The muscles operating this system begin at the spinal column, taking their origin from its whole length, and from this point to the fingers each successive member of the system is in a rapidly increasing ratio of complexity of structure as well as of function, and in a diminishing ratio of mere strength. Perhaps it scarcely needs demonstration that on the humerus, as the only single lever of this system, and the member upon which are exerted the fixing muscles from the trunk, while from it arise the greater part of the moving muscles of the hand, the actions are all concentrated. The exact conditions of the leverage must vary indefinitely with the motions executed by the limb, as well as with the postures it assumes; and in very many of them the muscles passing downward from the humerus combine the arm, forearm, and hand into one continuous lever, in which case the stress upon the humerus must be proportionately increased. Accordingly, the humerus is by far the strongest of the bones entering into the system.

Fractures of the humerus by direct violence need hardly be discussed, as regards the conditions of their production, since these are simple enough. Those produced by indirect violence, as by falls on the hand or on the elbow, or by striking a blow with the fist,¹ are not difficult of comprehension. And the cases of fracture by muscular action, which is generally the effort of throwing, take place in obvious accordance with the laws of mechanics. So many instances of this kind are on record, that it is scarcely necessary to refer to them. I may, however, mention one reported by Lyon,² in which a man, aged 30, had "a comminuted fracture of the right humerus, caused by violent muscular contraction in throwing a base-ball by the 'underhand' method. The bone was broken into several parts, extending from the lower to the

¹ Lonsdale, *op. cit.*, p. 166.

² *Trans. of Med. Society of Pennsylvania*, 1878.

upper third; besides this, several of the minor bloodvessels were lacerated to such an extent as to threaten gangrene." I know of no other case in which an injury of this kind resulted from such a cause.

Bellamy,¹ recording the case of a boy of 14, whose humerus gave way just below the insertion of the deltoid, as he was making a great exertion in throwing a cricket-ball, speaks of the twisting motion which is apt to be the finale of this act, as probably the real cause of the breakage; and this view certainly seems to be correct. The suddenness of the stress upon the bone is also to be taken into account.

As to the point at which the bone yields, whether above or below the insertion of the deltoid, this would appear to be determined by slight variations in the character of the movement executed. It must be borne in mind that, in the act of throwing, the humerus is steadied by its upper end against the scapula, its head rolling in the glenoid cavity, while its lower end describes a somewhat large arc, and carries the weight of the forearm and hand, the latter describing the largest arc possible to it. Under these circumstances the bone is acted upon by the deltoid, pectoralis major, and latissimus dorsi, much as the mast of a vessel is by its stays; and it yields just as the latter sometimes does when overloaded above.

By Malgaigne, Lonsdale, and others, cases are recorded in which the humerus has been broken in trials of strength; the opponents "facing one another, their elbows resting on a solid plane, their forearms touching by their ulnar margins, their fingers interlocked, and in this position each tries to turn outward the wrist and forearm of the other." Here the twisting mechanism is so evident that it need hardly be demonstrated.

In one case reported by Mr. Henry Smith,² a fracture of the humerus was caused by the attempt of the patient to lift himself by grasping the top of a wall.

Dr. W. B. Hopkins, in a recent article,³ has reported three instances of fracture of the humerus by muscular action. In one, the patient was throwing a base-ball "over-hand;" in a second, the man made a miss in striking a hard blow at another with whom he was fighting; and in the third, a woman was carrying a heavy tub of clothes.⁴

¹ Lancet, May 11, 1878.

² Med. Times and Gazette, July 25, 1857.

³ Philadelphia Medical Times, March 24, 1883.

⁴ In connection with these cases Dr. Hopkins says:—

"When the forearm is flexed at the elbow-joint by the contraction of the muscles of the arm, the lower end of the humerus acts as the fulcrum, the biceps and brachial muscles as the power, and the hand, with whatever it may grasp, as the weight. The forearm is, in other words, a lever of the third kind. In such the power must always be greater than the weight, technically expressed by the phrase 'mechanical disadvantage.' The amount of mechanical disadvantage to which the muscles of the arm are put to raise a known weight placed in the hand, is computed by multiplying the weight to be raised by its distance from the fulcrum, and dividing the product by the distance of the power from the fulcrum.

"The following measurements were taken from the bones of a well-developed male skeleton: From the bottom of the sigmoid cavity of the ulna to the metacarpo-phalangeal articulation of the middle finger, fourteen inches, and from the same point to the tuberosity of the radius, two inches. (For convenience in computation, the attachment of the biceps alone will be used, as it is the more important flexor muscle, and as it presents less mechanical disadvantage than the brachial.) The power, then, in this lever, is to the weight as seven to one. If, therefore, a weight of one hundred and fifty pounds is raised in the hand by flexing the forearm, the power exerted by the muscles in executing this movement is represented thus: $\frac{14 \times 150}{2} = 1050$

pounds—a force well calculated to part a tendon or break a bone.

"The fact that the forearm cannot be extended with as much force as it can be flexed, though with greater velocity, of course depends upon the difference in distance between the power and the fulcrum in the two cases. For, in the same specimen, the distance from the point of insertion of the tendon of the triceps in the olecranon to a point opposite the bottom of the sigmoid cavity of the ulna, was found to be only half an inch. The power, then, in this lever, is to the weight

One point of importance in the mechanics of the upper arm is the attachment of the forearm muscles, especially the extensors and supinator longus, the action of which, when the elbow is flexed, is to draw forward the lower part of the humerus, and thus to increase the forward angular deformity when this bone is broken anywhere below its middle. The effect of the contraction of these muscles is even more marked, as might be supposed, in fractures near the lower end of the bone, in connection with which it will be again mentioned.

In fractures of the humerus in children, the periosteum, by reason of its comparatively great thickness, may escape complete rupture, and there may be but little displacement. The same is generally the case in adults when the bone is broken by muscular action, or by slight violence. Sometimes, however, the fragments may be very widely separated, and occasionally the overlapping is so marked as to materially shorten the arm. In fractures by great violence, especially if compound, this condition of things may give much trouble. Pierson¹ gives a striking instance of this kind:—

“A seaman was brought under my care, who, forty-five days before, while at sea, had fallen from the maintopsail-yard upon the deck of the vessel, fracturing the humerus obliquely. The superior fragment penetrated the skin, and, after ploughing a furrow in the plank half an inch deep and two inches long, was finally broken off in it. On my first visit this fragment, which was about three inches long, was presented to me, which the captain assured me he had had much difficulty in extracting, two days after the accident, from the plank in which it had embedded itself.”

This man recovered with ankylosis, partial in the shoulder and complete in the elbow; the arm was, of course, shortened.

Syme² has reported a case of fracture at or about the middle of the humerus, the head of the bone being at the same time luxated into the axilla. The patient had fallen through a trap-door into a cellar, entangling the arm in a ladder as he fell. Reduction was effected by firmly splinting the bone, and then attaching an extending band above the seat of fracture. The subsequent progress of the case was satisfactory.

The *symptoms* of fracture of the shaft of the humerus are the same as those of the long bones generally: pain, loss of power, preternatural mobility, often deformity, and generally crepitus. Scarcely any fracture is less likely to present difficulties in diagnosis.

As to the *course* of these cases, in most of them union takes place favorably in from four to six weeks; but it must not be forgotten that the humerus has afforded more instances of pseudarthrosis than any other bone in the skeleton. In Agnew's tables, containing 685 cases of non-union, there were 219, or a little less than 32 per cent., in which the humerus was the bone involved. Out of the 219, the exact seat of the lesion is not stated in 52, leaving 167; and of these, 17 are said to have been of “the upper third” or “the surgical neck,” and 1 of the external condyle. Hence the shaft of this bone would seem to have been the seat of non-union in 149, or nearly 22 per cent. of the whole number.

Fractures of the humerus in children sometimes unite with great readiness. Thus, among the cases reported by Berry,³ there were three in which this bone was affected; in one consolidation had occurred on the 11th day, and in the other two on the 13th.

as twenty-eight to one. Therefore, when a sixty pound dumb-bell is put up from the shoulder, the force exerted by the triceps muscle is shown thus: $\frac{14 \times 60}{2} = 1680$ pounds, or 630 pounds

more force than is required to raise 150 pounds by flexion.”

¹ Remarks on Fractures, Boston, 1840.

² Edinburgh Medical Journal, July, 1849.

³ New England Med. Monthly, March 15, 1883.

It very often happens that fractures of the shaft of the humerus are united with scarcely any perceptible deformity; and in the Museum of St. Bartholomew's Hospital¹ there is a "section of a humerus, in which a fracture of the shaft at the attachment of the deltoid muscle has been exactly united, so that both the walls and the cancellous tissue are uninterruptedly continuous; and except by a slight deviation of its axis, and a small external deposit of new bone, the situation of the fracture could hardly be discerned." Sometimes, however, the deformity is very great, when the fragments are allowed to overlap one another; yet even in these cases the usefulness of the limb is not necessarily impaired.

The vessels and nerves, as a general rule, escape injury, except in cases of compound fracture. Laurent² relates one case, communicated to him by Richet, in which a boy ten years old had a fracture of the right humerus, one fragment of which wounded the brachial artery and gave rise to an aneurism, which was cured by ligation of the vessel above and below. Malgaigne quotes two cases in which suppuration ensued; but this is very rare. Instances of the almost complete absorption of this bone after fracture have been referred to in the general part of this article.³

Occasionally cases are met with in which, in the course of union of fractures of the humerus, nerves are entangled in the callus or pressed upon by it, with the result of causing pain or paralysis, or both, of the limb. Generally it is the musculo-spiral nerve which is thus interfered with. Trélat⁴ reports, that a young man, in consequence of a fracture of the left arm, had an exuberant callus which, by inclusion, caused paralysis of the parts supplied by the above-mentioned nerve. An operation was performed, the nerve being disengaged, and the projecting part of the callus being resected. Two months afterward movements began to be possible, and the functions of the limb were gradually restored. Tillaux is said to have referred to a similar case seen by him.

Gross⁵ speaks of having seen two cases of wrist-drop from pressure of callus upon the musculo-spiral nerve, in cases of fracture of the humerus; he says that the only remedy is the removal of the callus, but does not state whether by operation or by local medication; nor does he give the results in the two cases which he cites.

Agnew⁶ mentions such a condition, in a boy aged ten years, and says: "As the absorption of the redundant callus took place, and under the stimulus of an electro-galvanic current, his improvement was quite noticeable."

The *treatment* of fractures of the shaft of the humerus is simple enough in principle, but much difference of opinion has existed as to its details. Reduction can generally be effected without great difficulty, and the line of breakage is not often so oblique as to prevent the fragments from being kept in good position. Yet, as has been already stated, no other bone has offered so many examples of non-union. My own belief is that the true explanation of this fact is to be found in the leverage upon the lower fragment, exerted by the forearm and hand, which can only be counteracted by care in securing the whole arm—the upper fragment as well as the lower. No matter how exactly an apparatus is applied, if it does not extend upward sufficiently to get a purchase upon the portion of bone above the seat of fracture, there is danger of deformity, if not of failure of union. But if the fragments are controlled, the forearm may be simply supported in a sling across the front of the chest. I am inclined to urge this, from having more than once or twice

¹ Catalogue, vol. i. p. 139.

² Des Anévrysmes compliquant les Fractures, p. 42. Paris, 1875.

³ See page 45.

⁴ Gazette Médicale de Paris, 23 Déc. 1882.

⁵ Op. cit., vol. i. p. 976.

⁶ Op. cit., vol. i. p. 887.

seen cases in which angular splints had been carefully bandaged on, but not far enough up the arm; the effect being simply to convert the whole limb below the fracture into a powerful bent lever, by which the lower fragment was moved upon the upper, and the amount of callus augmented, with the chance of deformity, more or less permanent, as well as of entanglement of nerve-fibres, or of interference with the bloodvessels.

By the older surgeons, the use of an immediate bandage—a roller applied next to the skin—was considered indispensable for the prevention of muscular spasm. Such a bandage, although less objectionable here than in the case of the forearm or leg, can do no good, and may do harm by hindering the surgeon from accurately judging of the position of the fragments. It is, however, sometimes well to apply a roller to the hand and forearm, and perhaps to include the lower part of the arm itself, in order in some degree to prevent swelling of the distal part of the limb. But the bandage should never be carried up as far as the fracture, and the condition of the fingers should be watched, lest trouble arise from the pressure.

There are no landmarks by which, in the living subject, the proper line of the humerus can be clearly determined. Perhaps as good a test as any is, that the posterior surface of the upper arm being even and vertical, and the thumb held upward, the whole anterior surface of the forearm is in apposition with the side of the chest. Rotary as well as angular displacement is guarded against by observing this position in cases of fracture.

At the back of the arm, the firm and even mass of the triceps muscle, and in front that of the biceps and brachialis anticus, afford an opportunity for making very accurate and effective pressure on these surfaces of the bone. On the inner side, except in very muscular subjects, the projection of the epicondyle is such as to leave quite a marked hollow above it, but on the outer side the hollow, which is much less, is filled up by the deltoid above and by the outer borders of the triceps and brachialis below.

Stromeyer's cushion,¹ a sort of double wedge-shaped pad, upon which, interposed between the body and the limb, the latter rests, is sometimes of great use as a temporary arrangement, but can hardly be relied upon as a permanent dressing.

By some surgeons, it has been thought sufficient to confine the arm to the side by means of bandages, with an axillary pad in the form of a long, flat wedge. In very quiet and submissive patients this may answer; but it is safer to apply also four strips of wood, lightly padded, one on each aspect of the arm, confined either by adhesive strips or by a roller, and then to fasten the whole limb to the chest.

My own preference is for a right-angled splint of wood, extending from the axilla to the ends of the fingers, along the inner side of the limb; the angle corresponding to the elbow, and the arm-part, well padded, so as to allow for the projection of the inner condyle. In the case of a very lean adult, it is better to cut a hole with bevelled edges, large enough to permit the condyle to sink into it and thus escape pressure. Short slips of wood, binder's board or sole-leather, properly padded, are fitted to the anterior, posterior, and outer faces of the arm; the edges and corners of these small splints should be carefully bevelled. Adhesive strips an inch or more in width may be first put on near the ends of the splints, and then an ordinary roller; by this means the occasional removal of the latter for the purpose of examining the limb may be rendered safer. The limb, thus bound up, should be suspended in a sling passing under the wrist; and in children or restless adults, a few turns of a wide roller may be applied to confine the elbow to the side. When the frac-

¹ See Fig. 275, Vol. II. p. 160.

ture is above the middle of the shaft, the outer short splint may be extended upward into a shoulder-cap such as has already been described, and the roller continued upward, and made to form what is known as the "spica" of the shoulder, a few turns being carried around the upper part of the chest.

Bandages imbued with plaster of Paris, or other solidifying material, have been used by some surgeons in fractures of the shaft of the humerus, but they afford no special advantage, unless, perhaps, in the rare instances where a patient must undergo transportation, or, in the later stages of the treatment, if the dressings cannot be often examined. If applied during the earlier period they need to be carefully watched, lest the swelling of the soft parts should subside, and the requisite control of the limb be thus lost.

Let me again repeat, that the importance of so arranging the dressings as to secure the upper fragment can scarcely be overrated. The inside splint should extend well up into the axilla, only guarding against pressure upon vessels and nerves; and the outer one should bear upon the bone in its whole length. Sometimes additional security may be given by placing on the exposed surface of each of the splints a strip of adhesive plaster, doubled, so as to present its sticky side outward to the roller, as well as inward to the splint.

Sometimes it happens that extension is desirable to prevent overlapping of the fragments of the humerus. According to Swinburne,¹ this is the only thing needful in the treatment of these injuries; and he recommends the employment of an apparatus which certainly has the merit of simplicity. This consists in a board-splint, applied either on the outer, inner, or posterior surface of the arm, and attached to it below by loops of adhesive plaster for extension. Counter-extension is made from the axilla.

Ingenious splints on the same principle, but provided with ratchets for lengthening them, have been devised and used by Lonsdale,² Vedder,³ and others. The objection to all of these lies in the fact that the axilla is made the resisting point for the counter-extension, and that it is wholly unreliable for this purpose.

Harlan⁴ obtained great advantage by applying the counter-extending adhesive strips obliquely over the chest and back. He used in one case a wooden splint for the outer side of the arm, with a bracket screwed into its upper end for the attachment of the counter-extending band; and in the other, an iron bar of suitable length, bent at both ends.

Dr. H. A. Martin⁵ has employed an apparatus in which, while the counter-extension is obtained by strips applied to the front and back of the thorax, the splint itself consists essentially of a double iron bar, the two portions of which are movable upon one another by means of a ratchet and pinion, worked by a key.

I have myself attained the same object by employing a wooden splint applied to the outer side of the arm, but extending several inches beyond it upward and downward, the counter-extending adhesive strips being simply wound around the arm above the seat of fracture, while the extension was made in like manner from below.

¹ Treatment of Fractures of the Long Bones by Simple Extension. Albany, 1861.

² Op. cit., p. 174.

³ Vedder's splint may be found described and figured in the Medical and Surgical History of the War of the Rebellion, Part II., Surgical Vol., pp. 812 and 822. There is also here mentioned an ingenious expedient, suggested by Dr. Foster Swift, which consists in fastening together two forked branches so as to get a fork above and another below, to which the extending and counter-extending bands may be attached. Under some circumstances this idea might be carried out with very great advantage.

⁴ Med. and Surg. History of the War of the Rebellion, Part II., Surg. Vol., pp. 509, 562.

⁵ Ibid., p. 822.

Hamilton mentions that a plan, first suggested and tried by Clark of St. Louis, has been found satisfactory, viz., the attachment of a weight to the lower part of the arm by means of adhesive strips. Without questioning the statements in favor of this method, I must say that it seems to me to present certain practical difficulties in its carrying out, which are not easily met. The humerus must, of course, either be kept vertical, or the weight must pull it out of shape, and when the patient lies down the weight must be suspended over a pulley; but a slight change of posture would interfere with its action, or cause it to make traction out of the proper line.

A very complicated contrivance has recently been described¹ by Dr. Hubbell, of Colorado, having a crutch-head for the axilla, a screw for extension, a splint for the forearm, and a hand-rest; short splints are added if the fracture is not compound. It serves as an instance of the revival of old ideas in a slightly modified shape.

Dr. Hamilton has suggested a method of dressing these fractures, with a view of preventing or curing non-union, which is certainly original, and which can hardly be passed over, although I cannot say that it commends itself to my judgment. After referring to the peculiar tilting motion apt to be impressed upon the lower fragment, he proposes straightening the elbow, and applying a firm, straight splint from the top of the shoulder to the hand, making it fast with rollers. Not only would such a posture be awkward and inconvenient, but the tendency would, I think, be to tilt the upper end of the lower fragment forward, and thus to give rise to deformity.

In fractures near the lower part of the shaft of the humerus, the portion where the bone begins to widen out, there is apt to be a displacement of very marked character from muscular action. The flexors, pronators, and extensors all tend to pull the lower fragment forward, and, as it yields, its upper end must, of course, tilt in this direction; the triceps draws the olecranon upward, and anteriorly the biceps and brachialis anticus do the same. Hence the combined effect of all these forces is to tilt the lower fragment at an angle with the upper, as in Fig. 828. If union takes place under such circumstances, it must be clear that when flexion of the forearm upon the arm is

Fig. 828.

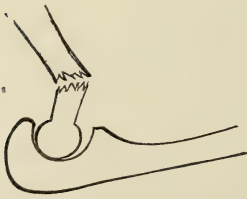


Diagram illustrating tilting of lower fragment in fracture of humerus near elbow.

Fig. 829.



Splint of binder's board for fracture of lower part of humerus.

attempted, it will be checked as soon as the coronoid process of the ulna comes in contact with the lesser sigmoid cavity of the humerus, and that in the changed position of the lower fragment the power of full flexion of the elbow must be lost. In order to obviate the tendency to this condition of

¹ Therapeutic Gazette (Detroit), May, 1883.

things, I long ago devised the splint shown in Fig. 829, which is intended to be cut out of the exact size required (ascertained by taking an outline of the sound limb). The material I generally use is binder's board, but sole-leather or patent felt would answer the same purpose, except in the case of unusually large limbs. The part marked *a* is bent so as to come in front of the arm; *b* is bent up behind the elbow, while *c, c*, are bent so as to give the forearm support and steadiness on the ulnar side. Properly proportioned and carefully applied, I think that this splint gives me more perfect control of a broken humerus, especially at the lower part of the bone, than I have succeeded in getting by any other. As consolidation progresses, it is my practice to cut away more and more of the splint at each dressing, so that the patient gains the use of the hand before the arm can be left to itself.

Another plan which would seem to promise well, in fractures of the lower part of the humerus, is to place the elbow at an acute angle, and keep it so for perhaps two weeks, when union may be supposed to have begun, and when the forearm may at each dressing be very slightly brought down, until at last the bones are found firm enough for complete passive motion to be attempted. By this method, entire relaxation of the flexors and pronators would be attained, and forward angular displacement could scarcely occur. Should it be found that the lower fragment projected backward, the angle of the elbow might readily be made more obtuse, and a short splint be applied along the posterior surface of the arm.

The subject of pseudarthrosis has already been discussed at such length in the general part of this article, that the treatment of such cases in this region need not be again spoken of here.

FRACTURES OF THE LOWER END OF THE HUMERUS, as has been already stated, and as may be seen from Gurlt's table quoted on page 118, are much more frequently met with than those of either the shaft or the upper end. In children this predominance is especially marked, since up to the tenth year the lower portion of the bone is broken considerably more than twice as often as both the other divisions put together. Between the tenth and the twentieth year the numbers become, in the set of cases upon which this table is based, exactly equal. Later in life there is a very great diminution in the liability of the lower part of the bone to fracture; but the fact must not be lost sight of that the shaft also shares in this decrease, so that the difference of proportion is not as great in reality as it would at first sight appear to be.

The boundary between the shaft of the humerus and what we call the lower end is not exactly defined; even less so, perhaps, than that between the neck and the shaft. It is a surgical and not an anatomical division; and a doubt may sometimes arise in regard to certain fractures, as to whether they should more properly be classed among those of the shaft, or with those of the lower end. But in general the cases which belong to the latter category present features which render them plainly distinguishable. One of these is the effect of muscular action, and another is due to the neighborhood of the elbow-joint; they will be further referred to directly.

Under the present head are included a variety of fractures, the principal lines of which are shown in the annexed diagrams (Figs. 830 and 831). Thus, there are cases in which the bone is separated more or less transversely, just above the condyles, the line of division sometimes running up along the outer or inner side of the bone so as to involve in the lower fragment nearly or quite a third of its length. Often, along with this, one or more lines of breakage pass downward into the joint. Occasionally the outer portion of the lower end only is involved, the condyle only, or with it the epicondyle, being broken off. Or the inner part of the lower end may be separated—the

trochlea, with or without the epitrochlea, or the latter process by itself. Finally, there are disjunctions of the lower epiphysis, or of its articular portion only.

It may, perhaps, be as well to say here that although these various forms of fracture can be thus enumerated theoretically, they are not in practice by

Fig. 830.

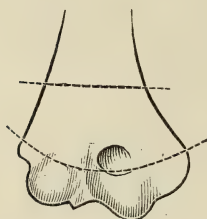


Diagram showing transverse fracture of lower end of humerus. The curved line shows complete epiphyseal disjunction.

Fig. 831.

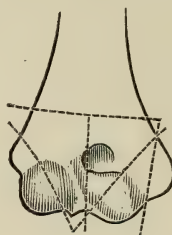


Diagram of T-fracture of lower end of humerus, with lines of fracture of internal condyle or trochlea, of epitrochlea, and of external condyle.

any means so easily distinguished. The lines of separation may run very irregularly; occasionally the combination of two or more fractures, or the existence of luxation along with fracture, may present a condition of things in the highest degree perplexing. But this matter will be more appropriately discussed in connection with the diagnosis of these injuries. Fractures of the *epicondyle* may, I think, be dismissed without further mention, since there is no case on record in which such a lesion has been verified beyond a doubt. It is true that Zuckerkandl¹ claims to have seen one, and that Gurlt figures a specimen. Sir Astley Cooper² also represents one, in which, however, the bone was "somewhat thickened," and the original lesion may have been more extensive. Fresh doubt is thrown upon these specimens by the statement of McBurney³ that "he had found in the dissecting-room similar isolated pieces of bone resembling detached epicondyles, and existing symmetrically at both elbows." Fractures detaching the epicondyle along with the condyle are, however, known to have occurred in numerous instances.

A careful study of the anatomy of the lower end of the humerus, and of the muscles attached to it as well as to the adjoining bones, is essential to the understanding of fractures in this region. Especial attention should be paid to the shape and extent of the epiphysis, in view of the fact that so many of the subjects of these injuries are at an age when it has not yet become consolidated with the shaft, and therefore when the question of its disjunction is apt to arise. The flattening of the bone antero-posteriorly as it widens out toward the condyles, and its consequent thinning, have already been mentioned, as well as the muscles by which the position, bent or extended, of the elbow-joint is controlled.

The epiphysis consists of four parts, developed, according to Gray, in the following manner: "At the end of the second year, ossification commences in the radial portion of the articular surface, and from this point extends inwards, so as to form the chief part of the articular end of the bone, the centre for the inner part of the articular surface not appearing until about the age of twelve. Ossification commences in the internal condyle about the

¹ London Med. Record, May 15, 1878, from Allg. Wiener med. Zeitung, Feb 1878.

² Dislocations and Fractures of Joints, p. 467.

³ Stimson, Practical Treatise on Fractures, p. 395.

fifth year, and in the external one not until between the thirteenth and fourteenth years. About the sixteenth or seventeenth year, the outer condyle and both portions of the articulating surface, having already joined, unite with the shaft; at eighteen years, the inner condyle becomes joined." (The reader will note that in this description the term "internal condyle" is equivalent to "epitrochlea," and the term "external condyle" to "epicondyle.") The importance of these facts consists in their bearing, not as much upon the separation of the epiphysis as a whole, as upon disjunctions of portions of it, which I have no doubt are more frequent than they are generally supposed to be.

Another matter of great moment in this connection is the anatomy of the elbow-joint. The trochlea, upon which the ulna moves as upon a hinge, drops at its inner margin considerably below the level of any other part of the joint, and thus locks in the articulating extremity of the latter bone. Hence, leverage through the ulna is often brought to bear most powerfully upon the lower end of the humerus, tending to twist it off; and if the epiphysis is yet ununited to the shaft by bone, its disjunction may ensue, while if it has already become consolidated, a fracture may be produced above. The radius, although it shares in the flexion and extension of the forearm, rotates freely upon an axis passing through the centre of its head, and hence is far less likely either to be itself broken, or to be the means of breaking the corresponding portion of the humerus.

As has been already stated, fractures occurring near the lower end of the humerus very often run into the joint; but even when this is not the case, the near neighborhood of the joint constitutes a complication of all these injuries, as its extensive synovial membrane inflames with extreme readiness, and the swelling from effusion into its cavity not only greatly increases the difficulty of recognizing the exact nature of the lesion, but also embarrasses its treatment.

In front of the joint, the median and the musculo-spiral or radial nerve, and behind it the ulnar, are in very close relation with the bone; so that either by actual pressure upon these nerves by the fragments, or by their injury or displacement, special symptoms, of no small importance, are not unfrequently induced.

The *causes* of fracture of the lower part of the humerus are very generally falls on the hand or on the elbow; they are in the former case due to indirect violence, in the latter to direct. Often, however, it is impossible to arrive at any certainty as to the way in which the hurt has been received, from the youth of the subject, or from the confusion and terror induced by the accident. It is highly probable that the tension of the muscles, in the effort to avoid falling, may have something to do with the production of the fracture, or at least with determining its seat and direction. As a general rule, even if in the act of falling the forearm is fully extended upon the arm, it becomes flexed to some degree when the hand strikes the ground; the ulna is forced against the humerus, and held there by the muscles before mentioned, so that there is a combination of leverage and muscular action, to which it is not surprising that the bone should yield. Still another condition favoring fracture is the irregular way in which the force is suddenly brought to bear, so that the stress comes, not in the axis of the humerus, but at an angle to it, as a "cross-breaking strain."

The *symptoms* in these cases, to be appreciated, must be observed at a very early stage, as otherwise the swelling which rapidly comes on, especially if the elbow-joint be directly involved, makes everything obscure, except the fact of fracture. By the direction of the fracturing force, as well as by the muscular action already repeatedly mentioned, the upper fragment generally presents itself, in fractures just above the condyles (to use Malgaigne's term)

in front of the lower. Occasionally, but very rarely, the lower fragment is found in front of the upper; this is probably due to the direction of the fracturing force, driving the whole elbow forward. Malgaigne has figured a case of this kind. And in any case, unless the injury has been the result of great direct violence, there is a tendency to the tilting forward of the lower fragment, and thus to the formation of an angle, salient forward. Thus the antero-posterior diameter of the arm just above the elbow is increased in a marked degree. Along with this change in the bone there must be more or less shortening of the arm, although this is seldom sufficient to attract notice. I think, however, that I have observed one sign of this, in the wrinkling of the skin at the back of the arm, just above the olecranon; but this disappears, or at least becomes less distinct, as swelling takes place.

Pain is nearly always present, and may be very severe; it is aggravated by the least motion of the elbow, so that the patient generally supports the arm and hand very carefully with the sound hand. There is, of course, total loss of power, involving the whole limb.

In many of these cases the abnormal mobility is clearly perceptible, and it can almost always be detected upon careful examination. Sometimes, indeed, it is so free as to be in itself puzzling, as in cases where from a transverse fracture there are two or more subordinate lines of breakage running downward into the elbow-joint. Here the sensation imparted to the touch, when the forearm is rotated on the arm, is that of a loose rattling; and, especially if swelling has already begun, it is difficult to get a starting point from which to measure the relations of the fragments.

When, however, there is any lateral mobility of the elbow, the fact of fracture may be regarded as established. In the complexity of the movements performed by the hand, we are apt to lose sight of the simplicity of the parts of the system upon which they depend. At the elbow, in the normal state, there is absolutely no motion except the hinge-like flexion and extension of the ulna upon the humerus, and the rotation of the radius upon an axis passing through the centre of its head, and thence downward through the ulnar border of its carpal articulating surface. When the forearm is semi-flexed on the arm, and the hand moved outward and inward, it seems as if there must be a lateral movement at the elbow, but this appearance will be found to be wholly due to rotation of the humerus around its long axis; the real motion is altogether confined to the shoulder. If the hand can be thus moved when the arm is grasped and held still, it is proof positive of the existence of fracture. Luxation does not free the elbow in any way.

When the upper extremity hangs by the side, with the elbow extended and the hand in supination, it will be seen at once that the elbow forms a very obtuse angle, salient inward, and that the hand hangs out from the side. Now, if without any rotation of the humerus at all, the forearm be fully flexed, it will be found that the hand comes up at the outer side of the shoulder, and that not even by the utmost pronation, with flexion of the wrist, can the end of the middle finger be brought opposite to the mouth. These facts are all accounted for by the outward slant of the trochlear portion of the lower articular end of the humerus, and are of great importance in the recognition, and especially in the treatment, of fractures in this region.

I have already referred to the muscles by which deformity is produced or kept up in fractures of the lower half of the humerus, and need hardly urge that the shorter the lever upon which they act, or, in other words, the lower the seat of fracture, the more direct and decided will be their influence. But it must be remembered that the line of separation of the bone is very seldom directly transverse; even when it runs almost directly across in front, as I have seen in a few specimens, there is apt to be irregularity somewhere in

the thickness of the bone, and this gives rise to a lateral tilting, by a mechanism too obvious to need more than mention.

Hamilton¹ has detailed a number of instances in which the ultimate effect of this displacement was clearly shown; and it has occurred to me to see it repeatedly. When union takes place without the correction of this angle forward, the articulating surface of the humerus is directed downward and backward, and the result is that flexion of the forearm is limited, while its extension may be abnormally increased. The reason why extension is not always thus increased, is sometimes the tension of the anterior muscles, the biceps and brachialis anticus, and sometimes the irregularity of the fracture at the posterior part of the bone, just above the joint.

Another effect of the abnormal mobility in question, which has been already hinted at, is the bringing up of the transverse line of the elbow-joint to a horizontal direction instead of the obliquity natural to it. This change is often favored by the treatment resorted to—as was long ago pointed out by Dorsey,² and more recently by Allis³—the result being to do away with the obtuse angle, salient inward, which the limb should present at the elbow, and to substitute for it a bending in the opposite direction. Such a condition, when existing in a marked degree, produces a very noticeable awkwardness at all times, and interferes with the strength and usefulness of the member in lifting and carrying, as well as in some other of its functions.

So far, I have been speaking only of fractures traversing the humerus just above its lower articulating extremity, whether accompanied or not by fissures running down into the joint. With regard to separations of the outer or inner angles of this extremity, of the epicondyle or epitrochlea, or of the epiphysis, it is impossible to lay down any distinct and definite statements, partly because of the small number of recorded cases, and partly because of the obscurity of the conditions attending these lesions.

As regards the *epitrochlea*, there can be no doubt of its occasional separation from the rest of the bone, the elbow-joint remaining intact. First described by Granger,⁴ this lesion has been recognized by Sir A. Cooper, Malgaigne, Gurlt, and others. But, as Gurlt remarks, the line cannot be sharply drawn between cases of this kind and those in which the fracture involves also the trochlea, wholly or in part. Cooper⁵ represents a specimen of the latter form of injury; he does not refer to any other, and the only case he records is that of a girl “who, by a fall upon her elbow, had fractured the olecranon, and also broken the internal condyle of the os humeri, the point of the broken bone having almost penetrated the skin.” Hamilton⁶ gives an account of eleven cases, examined by him at various periods after the occurrence of the injuries. In one only does he state positively that the fracture did not pass into the joint.

Six of these cases of Hamilton's have a special interest in reference to the permanent displacement of the fragment.

1. CASE 45. Examined seven years after the accident. “The apophysis is carried backward about two lines, and upward toward the shoulder about three lines.”

2. CASE 49. Examined after sixteen years. “The internal condyle was displaced forward.”

3. CASE 51. Examined after three months. “I find a fragment—the apophysis of the internal condyle—broken off, and removed downward toward the wrist one inch and a quarter, where it is immovably fixed.”

¹ Report on Deformities after Fractures. Trans. of Amer. Med. Association, vol. ix. 1856, p. 106.

² Elements of Surgery, vol. i. p. 145; also Plate V.

³ Annals of the Brooklyn Anatomical and Surgical Society, August, 1880.

⁴ Edinburgh Med. and Surg. Journal, April, 1818.

⁵ Op. cit., p. 466.

⁶ Report, etc., before quoted, pp. 110 *et seq.*

4. CASE 52. Examined after five weeks. "The inner condyle is displaced upward three-quarters of an inch. The olecranon process has followed this fragment. Large amount of callus in front at seat of fracture. The elbow is nearly ankylosed at an obtuse angle."

5. CASE 53. Examined after six years. "The internal condyle is displaced downward toward the wrist half an inch." Extension, flexion, pronation, and supination are stated to have been all impaired in this case.

6. CASE 55. Examined after five years. "The inner condyle displaced downward and forward half an inch."

The reader will perceive from the above quotations, I think, more distinctly than from a mere general statement, the influence of the muscles in producing and keeping up displacement of the fragment, when the epitrochlea, with or without part of the joint surface, is broken off. It will be noted that the separated portion had been moved in various directions—backward and upward, forward, downward (in two instances), upward, and downward and forward. When the fragment is drawn upward along the arm, it seems to me that it must be by portions of the triceps and brachialis anticus, the fibres below the fragment being probably torn across. Other displacements may be due to traction by the pronator radii teres, or by the superficial flexors. Very possibly the action is a gradual one, the separated portion of bone being drawn into its new position during the period preceding the organization of the callus. Certainly, in some cases there is at first distinct crepitus, showing that no such gap exists between the fractured surfaces as is brought about afterwards.

When a fracture runs obliquely into the elbow-joint, separating the outer or inner portion of the articulating surface of the humerus, it is not difficult to see how in the former case the radius, and in the latter the ulna, loses its support, and, under the influence merely of the muscles, pushes the fragment before it. Sometimes the fracturing force itself may cause the displacement, and in that case the muscular action would surely tend to keep up the derangement of the parts. An obvious result of either disturbance of relation must be to twist the forearm into an abnormal direction, and, by changing the position of the points of origin of muscles, to interfere with some actions, while others are made more free, although less powerful. Pick¹ has recorded a curious case of fracture of the *external condyle*, the fragment having been carried up and attached to the outer side of the bone. Hunter² met with a case in which the external condyle was broken off, the radius and ulna being at the same time luxated outward. The fragment "had apparently become wedged in between the bones forming the elbow-joint," and reduction was impossible. Strength was regained in the joint, but not much motion.

In 1856, I saw a washerwoman in whom a fracture of the *inner condyle* had resulted from muscular effort in lifting a heavy tub. The accident had occurred some two months previously; there was much effusion into the cavity of the joint, and the head of the radius was widely separated from the ulna, but some use of the arm remained. The nature of the lesion was quite clear, and the patient's account of the matter plain and straightforward. I do not know any further history of the case.

Disjunction of the *lower epiphysis* of the humerus is an accident which can of course happen only in childhood or youth. It is probable that here, as elsewhere, the line of separation may not always be exactly confined to the cartilage, but that a portion of the bone may be torn off. On the other hand, I think the fracture may concern a portion only of the epiphysis, and thus be entirely within the joint. The cases of this kind which have come under

¹ Trans. of London Pathological Society, 1870.

² Philadelphia Med. Times, April 1, 1871.

my notice have been in children, and the mechanism of their production was not known. On passive motion of the elbow, distinct crepitus was elicited, and no other sign of fracture existed except loss of power in the limb, and pain, aggravated by handling; there was no perceptible deformity. The limb was in each case kept at perfect rest by means of an angular splint, and in the two cases of which I have kept notes, complete recovery ensued in about six weeks.

When the epiphysis is separated as a whole, the epitrochlea and epicondyle are of course included in the lower fragment, and the line of division curves downward above each of them, to run almost transversely above the edge of the articular surface. In the cases of this kind which I have seen, the lower fragment has always been carried backward, the radius and ulna following it, and the lower end of the upper fragment projecting somewhat strongly in front of the elbow. I think that the anterior edge of this fragment corresponds pretty nearly with the fold of skin at this point. All motion of the part is painful, and there is especial difficulty in flexion; crepitus is easily detected. The antero-posterior diameter of the joint is increased, and swelling comes on with great rapidity, augmenting the deformity and in great measure obscuring the condition of the parts.

The *course* and *ultimate result* of fractures of the lower part of the humerus is apt to be very unsatisfactory. *Inflammation of the elbow-joint* is commonly set up, and although it may be actively combated, and may not run high, a certain amount of stiffening is almost always induced; this, as a general rule, is in time overcome, but there is often left a tendency to occasional attacks of pain and tenderness.

A curious point may here be noted, namely, that in some cases the stiffening of the elbow may be limited to the ulnar portion of the joint. Thus Lallemand¹ had a patient aged thirty-two years, who, in consequence of a crush of the elbow, opening the joint extensively, had the humero-cubital articulation ankylosed, but the radius was still capable of motion on the ulna, and with some supplemental aid from the shoulder-joint all the motions of pronation and supination were accomplished. In one of Hamilton's cases,² a fracture of the inner condyle, he found that "the arm was nearly ankylosed in a rectangular position; pronation and supination were perfect."

The inflammation of the elbow occasionally leads to more serious results. In one case recorded by Wright,³ a strumous boy, aged twelve, had a fracture detaching the capitellum of the humerus, which gave rise to pulpy degeneration, for which excision of the elbow was performed.

Perhaps it may be regarded as strange that the *vessels* so seldom suffer in these fractures, but in fact they are not only separated from the bone by a thick layer of soft parts, but are by their flexure in a position to yield readily, and thus to escape tearing. When the fracture is a compound one, however, the course of things may be different.

Fig. 832 represents a fracture of the humerus in a boy, aged about twelve, who fell from a low fence; the upper fragment was forced out through a

Fig. 832.



Fracture of lower end of humerus.

¹ Am. Journal of the Med. Sciences, Jan. 1841; from *Lancette Française*, Mai, 1840.

² Report, etc., p. 111; Case 48.

³ Guy's Hospital Reports, 3d ser., vol. xxiv., 1879.

wound in front of the arm, and the artery was torn completely across, rendering amputation necessary.

Sometimes, but more rarely than might perhaps be supposed, the circulation is interfered with by ill-applied apparatus, as in a case recorded by Wright,¹ in which by the pressure of an anterior angular splint, in a case of separation of the lower epiphysis of the humerus, the artery was occluded for twenty-two days; no permanent harm, however, resulted.

Occasionally, serious damage is done to *nerves* in connection with the fractures in question. The close relation of the ulnar nerve to the bone would seem to involve it in constant danger; yet the usual character of the displacement, the lower end of the upper fragment going forward, is obviously such as to diminish the risk. Callender² gives a number of cases in which this or the median nerve suffered, and suggests that they may become adherent, and be stretched by sudden movements. Lange³ has recorded the case of a girl, aged eight, who, after a supra-condyloid fracture of the humerus, had pain at the seat of injury, the wrist and fingers being flexed, with a very limited degree of motion. A sharp edge of bone could be felt. Electricity, massage, and systematic movements were tried for six weeks, at first with some apparent success. An operation was performed, and the median nerve found flattened against the edge of bone; above this point it was thickened and swollen. The nerve was loosened, and the edge of bone excised, with decided relief to the symptoms. "There was one interesting point, namely, that since the operation an entirely different and more normal form of nail was growing, and there were ridges on all of the nails alike, marking the parts before the operation from those afterward. The color and temperature of the skin had also markedly improved."

Another danger in these cases is from the *abnormal or excessive development of callus*, which however happens more rarely here than in some other regions. In the Museum of the New York Hospital⁴ is a specimen of T-fracture at the lower end of the humerus, in which the ulna and radius are ankylosed to each other and to the external condyle by bone effused between their contiguous surfaces. A case is recorded⁵ in which Mr. Croly excised the elbow-joint of a man about thirty years of age, who had about fifteen months previously sustained a fracture of the joint. A large amount of callus prevented flexion of the joint or use of the fingers. The olecranon, the head of the radius, and the end of the humerus were removed; the coronoid process was left in order to keep the brachialis anticus muscle intact. The ultimate result is not stated.

Malgaigne refers to a case, seen by Monteggia, in which tetanus ensued upon a simple fracture near the lower end of the humerus, and proved fatal, although amputation was performed.

As to the *diagnosis* of these fractures, it presents in some cases little or no difficulty, while in others it is more or less obscure, and occasionally extremely so. Much depends upon the time which has elapsed between the receipt of the injury and the examination, since often a very few hours suffice for the occurrence of such swelling as to completely mask the parts. Under such circumstances the patient should be placed under the influence of an anæsthetic, and the utmost care used in determining whether or not there is luxation of the bones of the forearm—a point which can generally be decided, if in no other way, by the degree to which passive motion can be made. This is a matter of the utmost importance, as the reduction can be

¹ Ibid.

³ New York Medical Journal, April 28, 1883.

⁴ Catalogue, p. 68.

² St. Bartholomew's Hospital Reports, 1870.

⁵ Lancet, Feb. 17, 1883.

far more easily effected at once than at any later period; but its discussion belongs more appropriately elsewhere.

As a general rule, fractures in this region resemble luxations in the abnormal projection backward of the olecranon; in fact, the two lesions are often undistinguishable from one another by the mere appearance of the parts. (In both, the elbow is slightly flexed; although some authors have represented it as fixed, or nearly so, at a right angle, when luxated. The former has been the position in the eight cases of children and boys which have come under my own observation, and this experience is confirmed by that of Malgaigne¹ and Hamilton. In adults I have seen the elbow quite rigid, and semi-flexed; but the other condition obtains sometimes in them also.) But in case of fracture, if the surgeon places his thumbs in front of the projection of the humerus, he can with his fingers press the olecranon forward into its normal place, and keep it so until he relaxes its hold. Dislocations, I need hardly say, are often very difficult to reduce, and are very unapt to recur.

Dislocation having been set aside, the surgeon's attention should be directed to the allaying of the inflammation by the usual means, the limb being kept in the most comfortable posture; and as soon as possible the attempt to establish an accurate diagnosis should be renewed.

Either before the occurrence of inflammatory swelling, or after it has subsided, the eye may detect certain abnormalities in the shape of the limb. One of the most important of these is the increase of its antero-posterior diameter either at or just above the elbow. Another is the change in the relative directions of the axes of the arm and forearm. Still another is a widening of the arm transversely at the elbow. But when either or all of these signs are present, they need to be interpreted by means of further investigation.

If, upon applying the fingers to the bend of the elbow, or perhaps a little above it, the more or less sharp and ragged edge of the upper fragment is felt, the fact of fracture is established; in case of luxation, the rounded articular surface of the lower end of the bone would present itself. The processes commonly known as the condyles, but more correctly as the epicondyle and epitrochlea, should now be found—as they often can be even where the parts are swollen—and pressure made through them across the bone. If pain be thus caused, a fracture running into the joint may be suspected; if crepitus, it may be regarded as certain. Unless swelling have occurred, it may be possible to grasp the epicondyle or the epitrochlea between the thumb and finger, and determine its mobility or fixedness upon the rest of the bone. The attempt may be made also to sway the forearm from side to side, which ought not to be possible. In so doing, crepitus may be elicited.

Upon making passive motion, flexing and extending the elbow, and pronating and supinating the hand, it will be found, if there be fracture, that in one or more of these movements there is crepitation. If this occur in flexion only, or in flexion and extension, it may be that the humerus is simply broken across; but if every motion develop it, the probability is that the joint itself is involved.

Measurement may now be made of the breadth of the joint, from the epicondyle to the epitrochlea, and it may be compared with that of the sound limb. The best means of doing this is of course a pair of callipers; but as these are not likely to be at hand, resort may be had to other methods, the simplest being to apply the back of the elbow to a plane surface, on which a sheet of paper has been placed, and then to put a book on either side of it, standing edgewise on the paper. The distance between the lower edges of

¹ Op. cit., tome ii. p. 576.

the books being marked on the paper, the same may be done for the sound elbow, and the two measurements compared. An increase in the width may be regarded as probably due to fracture involving the joint.

Wright¹ gives two test-lines which may be useful in the diagnosis of injuries about the elbow. He says that it will be found "that a line can be drawn in all positions of the joint, from the most prominent point of the internal condyle, through the upper border of the olecranon, obliquely downward and outward to the head of the radius, and that such line is bisected at a point corresponding to the superior and external angle of the olecranon." The relation of these points to the line would obviously be altered in case of fracture of the olecranon or of the inner condyle. Wright says further: "If also a line be drawn across the back of the joint in full extension, from the external to the internal condyle, or *vice versâ*, that line will lie above the upper border of the olecranon, or, in other words, the angle it forms with the first test-line will be on the distal side of the inter-condyloid line. This line is most conveniently taken by extending the arm horizontally, with the humerus rotated so that the bicipital or anterior aspect looks toward the middle line of the body, and dropping a perpendicular through the condyles."

There is one condition in which the test afforded by these lines would fail, that, namely, of a separation of the articulating portion only of the humerus. Here the relation of the condyles (epicondyle and epitrochlea) to the olecranon would be changed, perhaps indeed in a very slight degree, but still perceptibly; yet the inference that the case was one of luxation and not of fracture would be incorrect. Here, however, the application of the other means of diagnosis, the development of crepitus, and the fact of the ready correction of the slight displacement, together with that of its equally ready recurrence, should suffice to prevent any mistake.

The significance of a change in the relative direction of the axes of the arm and forearm must depend upon the other features of the deformity. If, for instance, the obtuse angle before noted as existing at the normal elbow is done away with, it may be either by a fracture across the humerus just above the joint, or by the separation of the trochlea, or by luxation backward of the ulna and forward of the radius. If it is rendered more acute, there may be fracture of the outer angle of the lower end of the humerus, allowing the head of the radius to slip somewhat backward; or, the humerus being broken very low down, there may be a slight twist of the short lower fragment upon the upper.

The foregoing statement embraces the leading facts in regard to the diagnosis of these injuries; but in practice there are shades of difference in the phenomena presented, which it would be in vain to attempt to set forth. I do not hesitate to say that no class of cases demand more care, tact, and judgment for their detection and discrimination, than those involving the elbow.

As to *prognosis*, the surgeon should always bear in mind the fact that the elbow-joint is apt to be at least temporarily stiffened after injuries in its neighborhood; and that a slight displacement of the fragments, when the lower part of the humerus has been broken, may give rise to a permanent limitation of mobility. Hence he should be very guarded in his promises of complete restoration of the functions of the limb; and it is much better to warn the patient, or the friends in the case of a child, that stiffening of greater or less duration is likely to occur. If the fracture can be clearly made out to be entirely above the joint and above the line of the epiphysis, the prospect for complete recovery is more promising than if the joint be involved; yet

¹ Loc. cit., 3d ser., vol. xxiv. 1879, p. 54.

even here, unless the tilting of the lower fragment, before spoken of, can be prevented, there will be some limitation of movement. Moreover, this limitation is permanent, and not to be diminished by any treatment; which is not usually the case with mere stiffening of the joint.

I have occasionally seen in adults, after injuries of this kind, the stiffening recur from time to time, unless guarded against by continual exercise; and it is, of course, well to mention the possibility of such a result beforehand.

The *treatment* of fractures of the lower portion of the humerus presents difficulties of a very serious nature. Supposing the diagnosis to have been clearly made out, the object of the surgeon must of course be, in accordance with general principles, to correct any existing deformity, and to maintain the fragments in their normal relation until union shall have occurred. But plain as the indications are, the fulfilling of them is by no means easy, nor, as before stated, are the results apt to satisfy either the surgeon or the patient.

The difficulties referred to are four: to keep the fragments in contact and at rest; to prevent the formation of an angle, salient anteriorly; to maintain the oblique line of the articulation by avoiding upward pressure on the inner portion of the joint-surface of the lower fragment; and to obviate stiffening of the elbow.

As to the first of these difficulties, it is due to the extreme shortness of the lower fragment, which gives very little purchase to any confining apparatus; in the case of T-fractures, or separations of the trochlea, the tendency is to a forcing apart of the articulating surfaces, or, what is equally bad, a gaping of the fractured portions above, and, perhaps, the insertion between them of part of the upper fragment. In epiphyseal disjunctions, the correct position of the detached portion is almost wholly a matter of conjecture, and must of necessity be so, until a favorable result affords proof of it. Now, if an anterior angular splint, or two lateral ones, be carefully applied to a sound arm, it will be found that a certain amount of rocking motion can be given, with the effect of loosening somewhat the upper portion of the bandage; should the same thing be done in a case of fracture, it may readily be seen that the part of the limb below the breakage is converted into a bent lever, the short arm of which is the lower fragment; and upon this a very slight amount of force applied to the hand will act most powerfully. Hence, scarcely any good can be expected from means of fixation of this kind, unless bound on so tightly as to endanger interference with the vascular supply, or with the innervation of the limb.

The force of this statement is still greater, if the fact is considered that the parts about the elbow are apt to be largely swollen at the time of the first dressing, and that a daily subsidence of the swelling must be looked for, so that the controlling power of any apparatus is continually becoming less and less, until the inflammation has gone down and its products have been absorbed.

Of the second difficulty I have already spoken at some length, so that it need not be further discussed at present until the details of treatment are taken up.

The third difficulty is one which has been more fully appreciated of late years than formerly. Dorsey, as already said, pointed out the frequent occurrence of deformity from the substitution of an angle, salient outward, for the normal one, salient inward; and Allis has recently, with much force, called attention to the same point. Yet it seems to me that the real source of the trouble is the want of recognition of the obliquity of the line of the articulation, and the application of dressings, no matter in what position—flexed or extended—which press straight across the front of the joint, and thus by their posterior bearings push the trochlea upward, and force the upper

and inner angle of the lower fragment past the corresponding portion of the upper fragment, whether behind it or in front of it. Allis's method, putting the forearm in extension, with the normal angle maintained, and keeping the limb in this posture by means of the plaster-of-Paris or starched bandage, or other form of immovable apparatus, is a very sound one in theory, and no doubt has given good results. But I believe that the same advantage may be gained by other means, and perhaps with more comfort to the patient, if only the normal shape of the joint be borne in mind. Any one may readily satisfy himself, by inspection of a sound arm, of the obliquity of the anterior fold of the elbow; and a glance at the skeleton of the limb will show that the line between the bones corresponds with the furrow in the skin.

The means of preventing stiffening of the elbow will be spoken of hereafter.

Now, as to the special plans of treatment of these fractures, they may be classed as those without apparatus, those with apparatus for maintaining flexion, and those with apparatus for keeping the limb extended.

The principle of treatment without apparatus is merely to suspend the limb in a sling, the elbow being flexed, and to favor a certain amount of change of angle of the joint, in order to obviate stiffening. I have heard the opinion expressed by a surgeon of large experience and high reputation, that the formation of a false-joint near the elbow was by no means a misfortune; he had seen a number of cases of permanent disability from ankylosis of the joint, the fractures having united. But I do not believe that it is necessary to run the risk of deformity by leaving the joint uncontrolled, lest it should stiffen; nor does it seem to me that the favoring of a pseudarthrosis to take the place of such a joint as the elbow, is a good surgical procedure. The only proper aim, in dealing with the cases in question, must be to obtain union of the fracture, and to preserve the mobility of the elbow; and my conviction is, not only that these ends can in the majority of instances, by due care and attention, be accomplished, but that any other course would justly fail to receive the approval of the profession.

Various plans have been proposed and adopted for treating these fractures in the flexed position. By some surgeons, a rectangular splint has been employed, extending along the whole posterior surface of the limb; and to this Sir Astley Cooper added an anterior arm-splint to correct the angle forward. Physick's splints, also rectangular, and applied along the lateral surfaces of the arm and forearm, had for many years a popularity in this country, due more to the name of their advocate than to the excellence of the results obtained with them. To these succeeded the anterior angular splint, somewhat hollowed to fit along the front of the arm and upper surface of the supinated forearm.

Physick's splints, as used by him, and I believe by all of his followers, were made of wood: for the others, wood, tin, binders' board, gutta-percha, and felt, have been employed. My own practice has been to use binders' board, shaped as shown in Fig. 829, giving the lower edge of the part applied to the front of the arm an obliquity corresponding to that of the crease at the bend of the elbow, and bevelling it off so as to avoid painful pressure on the skin. The advantage obtained in the pressure of the upper part of the lower fragment backward, while the olecranon is pushed forward by the projection at the angle of the splint, bent around against it, has seemed to me to be very great.

Another plan, which I think would answer well, although it has never to my knowledge been employed, would be to place the forearm in a state of flexion at a somewhat acute angle, keeping the hand semiprone, and directed a little outward, so as to maintain the normal angle before referred to. In this way

the projection forward of the upper end of the lower fragment would be in great measure, if not altogether, obviated, since the muscles which cause it would thus be relaxed. The posture, although not as comfortable for a length of time as the rectangular, would still not be unendurable, and would not need to be maintained after the process of union had begun.

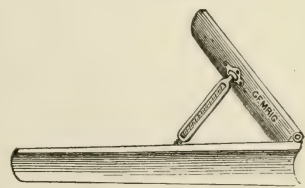
The method by extension, advocated by Allis, has already been described. It is recommended also by Ingalls.¹

A most important matter, in the treatment of all these cases, is the making of passive motion. This ought, in my opinion, always to be begun as early as possible; but the proper time varies with circumstances. When the line of fracture is wholly outside of the joint, and the latter does not become swollen by effusion within its cavity, I think it well at the very first dressing to grasp the lower part of the arm firmly, but gently, and to slowly and quietly make flexion, extension, pronation and supination, not to extreme degrees, but freely enough to exercise the whole joint. Properly done, this process involves no risk of disturbing the fragments, nor is it followed by any pain, tenderness, swelling, or other evidence of inflammation. Even if the joint is involved in the breakage, I think that as soon as the inevitable inflammation has subsided, passive motion may be very gently made, and with advantage; perhaps, at first, the movements may be limited to pronation and supination, and flexion may be added subsequently, extension being postponed on account of the risk of tilting the lower fragment forward. Should marked irritation ensue, it may be allayed by hot fomentations, by poulticing, or by the local use of lead-water and laudanum, and no further attempt should be made for a few days, perhaps for a week.

When stiffening of the elbow has already occurred, whether early or late in the progress of the case, it is very desirable to overcome it; and the means to be adopted with this view must vary according to circumstances. If it is early, an attempt should be made to change the angle from day to day, or oftener. This may be done either by employing different splints, with slightly varying angles, substituting at each dressing a fresh one, or by the use of a single splint with a hinge corresponding to the elbow, and with the two portions movable by means of Stromeier's screw (Fig. 833). A modification of this appliance has lately been proposed by Keen, consisting simply in attaching the screw by curved arms, so as to place it well over at one side, and avoid interference with the bandaging of the arm to the splint. I think advantage is sometimes gained by poulticing the joint for a day or two previous to attempting to change the angle. Violence should never be used in these cases.

An important point to be noted is the degree to which flexion can be made, and the character of its limitation. If the forearm is checked at an angle of say 30° , there is reason to believe that the lower fragment is tilted forward; and this is the more likely if extension can be carried beyond its natural limit. In such a case, it becomes a question whether an attempt should be made, under anæsthesia, to correct the abnormal position of the lower fragment, or to do the same thing by gradual means—changing the posture of the limb by dressing it in a state of flexion; or it may be, especially if the previous history of the case shows the joint to be readily inflamed, that the more prudent course will be to let things remain as they are, notifying the patient or his friends that there will, probably, be a permanent limitation of movement.

Fig. 833.



Hinged splint for elbow, with Stromeier's screw.

¹ Medical News, Jan. 7, 1882.

As extension is made, the degree to which the normal angle between the axes of the arm and forearm has been preserved, should be noticed, and if it has been lost, the propriety of an effort to restore it must be obvious.

Compound fracture of the lower extremity of the humerus, not involving the joint, is of rare occurrence. It differs from simple fracture of the same part mainly in the difficulty of treatment, and in the risk of inflammation of the joint, with consequent stiffening. Almost always due to great direct violence, it may present any of the forms before spoken of, with like displacements.

When the elbow-joint is involved, the lesion is a very serious one, and is extremely apt to be followed by ankylosis, in spite of all the efforts of the surgeon. The fact that the joint is opened is generally revealed by the escape of synovia; but the absence of this symptom does not prove that the joint is intact.

When the external wound is large enough, an exploration may be properly made with the finger; but if otherwise, the ordinary rule should be followed, to close the orifice at once as completely as possible, in the hope that it may heal, and thus render the fracture a simple one. Occasionally, if the bone seem to be extensively smashed, with only a small skin-wound, the latter may be enlarged by incision. The injury to the soft parts is very generally on the posterior face of the limb, unless it be due to the projection forward of the upper fragment, in which case, as in one instance before mentioned, the vessels or nerves, or both, may have sustained damage. Amputation is sometimes unavoidable.

The advocates of Listerism advise that, if the joint has been entered, it should be washed out with carbolized water, with the view of destroying germs, and thus preventing suppuration. I believe that the practice is followed by good results, but not on the theory just mentioned. It is a matter of observation that, when any serous membrane is laid open, pure water applied to it acts as an irritant; and the anæsthetic property of carbolic acid is also a known fact. By virtue of this, a weak solution of the acid may, it seems to me, prevent the inflammatory action which would naturally follow the admission of air to the joint-surface. Dirt or other foreign matter forced in at the time of the receipt of the injury must be carefully washed out, and for this purpose the carbolized water answers as well, if not better, than anything else.

When the fracture, besides being exposed to the air, is comminuted, it is important for the surgeon to see that any loose fragments are removed, and that those that remain are in proper place. Otherwise, even if the joint continue free from adhesions, its motions may be interfered with, and the usefulness of the member be proportionally lessened.

A small wound may be closed with lint and collodion, or with any good, non-irritant adhesive plaster. Another excellent plan is to apply lint saturated with Peruvian balsam. Good results have also been attained by the old plan of saturating lint with the blood, and allowing it to dry over the wound. For the first few days, until the subsidence of the acute inflammatory condition which must attend an injury of this kind, the application of a splint is needless, unless it be merely a wide rectangular one, well padded, upon which the limb can be laid for the purpose of keeping it steady. Irrigation may, in these cases, be sometimes employed with advantage. When the wound has healed or has begun to suppurate, and the swelling has gone down, attention must be paid to the position of the fragments, as well as of the forearm and hand. Ankylosis is so likely to occur, that it is important to arrange the limb in such a way as to make it most useful even with a stiffened elbow; the proper plan is therefore to flex the forearm at an angle of about 90° , and to keep the hand semi-prone.

When the services of a skilled mechanic can be had, some form of bracketed splint, one portion to fit the front of the arm, and the other that of the forearm, may be employed. Or, by a little ingenuity, the surgeon may adapt a strip of tin, of sheet-zinc, or of hoop-iron, so as by means of a plaster-of-Paris bandage to control the limb properly. In either case, a sufficient space should be left opposite the wound for the application of suitable dressings. When there is much discharge, cleanliness requires that the renewal of the dressings should be frequent; and it is well to protect the adjacent edges of a plaster-of-Paris bandage, either by a strip of oiled silk folded over them, or by a coating of varnish.

As to the character of the dressings to be employed, nothing need be said here, the subject having been fully discussed in previous portions of the *Encyclopædia*.

Before dismissing the subject of fractures of the humerus, I wish to add a case which came under my notice too late to be mentioned in its proper place. It is recorded by Mr. R. Jones,¹ and was that of a man, age not given, who fell from a height, and in falling grasped at a door. He thus sustained a subclavicular dislocation of the right humerus, which bone was broken at the middle, and a dislocation backward of the elbow. The fracture was secured in splints, and the dislocation reduced. Some effusion occurred in the elbow-joint on the third day, but was rapidly absorbed; and the movements of both elbow and shoulder were free and painless in six weeks. He had previously dislocated both hips, and on three occasions the left shoulder.

Fractures of the elbow, properly so called, in which not only the lower portion of the humerus, but the upper portions of the bones of the forearm, are involved, present certain special features which entitle them to separate consideration. They can, however, be more suitably spoken of after the discussion of fractures of the last-mentioned parts.

FRACTURES OF THE BONES OF THE FOREARM.

Taken collectively, the fractures of this part of the skeleton constitute a very large proportion of the whole number of these injuries. Wide differences exist, however, between the two bones of the forearm, as well as between the different portions of each, in regard to their liability to fracture. Thus, the ulna by itself is rarely broken, especially at its lower part; the radius by itself is almost exempt above, but fractures near its lower extremity are among the most common of accidents. Both bones may give way at once, to a crushing force, in any part of their length; but more frequently they are broken by indirect violence, somewhere near the middle, or below it.

The order of frequency of these accidents may therefore be stated as follows: The radius alone near its lower end; both bones about their middle third, or in the upper part of the lower third; the olecranon; the coronoid process; the radius alone near its upper end; the ulna alone in its lower part.

Now these differences, far from being unaccountable and as it were capricious, find a clear explanation in the anatomy and mechanical conditions of the forearm and of the bones themselves; as does also the fact, at first sight strange, that the thickest and seemingly the strongest portion of each bone is the one which most frequently gives way.

¹ *Lancet*, April 28, 1883.

FRACTURE OF THE OLECRANON is very rare in children, although it is mentioned three times among the 316 cases in the records of the Children's Hospital, before quoted, while Malgaigne quotes three cases recorded at the Hôtel Dieu between the ages of eleven and fifteen. Holmes¹ figures a specimen of "fracture of the cartilaginous epiphysis of the olecranon," but does not mention the age of the patient; the head of the radius was dislocated forward.

By far the most common cause of this injury would seem to be falling upon the elbow, the joint being strongly flexed at the moment. A blow, or any other direct violence, may cause it in like manner. An old woman once came under my care, who had fallen down in ascending a staircase, striking her elbow on a pebble which lay on one of the steps, and breaking the olecranon. Muscular action has been thought to produce this fracture in a number of cases, although Malgaigne, while admitting four, says that "instances of this kind call for careful scrutiny." Dupuytren² says: "A sudden and very violent extension of the forearm, by the action of the triceps, may also produce fracture of the olecranon, which happened whilst I was a student, to a person who, whilst playing at tennis, gave the ball a violent back-stroke with the racket, and immediately felt a sharp pain at the elbow. I examined the arm, and found that the olecranon was fractured."

It must be remembered that the triceps is not inserted into the tip of the olecranon, but "into the back part of its upper surface, a small bursa, occasionally multilocular, being interposed between the tendon and the front of this surface."³ Moreover, the tendon of the triceps, expanding over the upper and back part of the ulna, gets a much larger attachment than merely to the upper surface of the olecranon, and the "tearing off" of this process, described by some surgical writers, is actually impossible. In one case, quoted by Malgaigne from Veyne and Robert, it is said that these surgeons "made out a detachment of the apex of the olecranon;" and this is the only one of the instances mentioned by Malgaigne in which the exact seat of the fracture is stated.

Lonsdale⁴ suggests that fracture of the olecranon may sometimes be explained "by the ulna being thrown back against the humerus with great violence, which motion produces extreme extension, and throws the olecranon process forcibly against the humerus, which may be sufficient to break it off from the rest of the bone;" I may say that this idea had crossed my own mind, but that it had seemed to me that the anterior attachments of the forearm, both muscular and ligamentous, would prevent such extreme extension.

The olecranon may give way at either of several points. Sometimes the line of fracture runs through the slightly constricted part which corresponds to the middle of the sigmoid cavity, as looked at from the side. Sometimes it passes across the middle of the process, and occasionally it is much closer to the apex. In one specimen in the Warren Museum,⁵ in Boston, there is a double fracture, with close fibrous union. "The lines of fracture are, respectively, $\frac{1}{2}$ inch and $1\frac{1}{3}$ inches from the extremity of the bone; and at this last the union was so close that it only appeared when the pieces were separated by maceration." Very probably there is often a certain amount of crushing of the edges of a fracture produced by direct violence, but the above is the only instance known to me of double fracture.

The direction of the line of fracture varies, although it would seem to be mainly transverse.

¹ Surgical Treatment of Children's Diseases, p. 265, Fig. 45.

² Diseases and Injuries of the Bones, Syd. Soc. Transl., p. 37.

³ Gray's Anatomy, Descriptive and Surgical, p. 305.

⁴ Op. cit., p. 154.

⁵ Catalogue, p. 171.

Both olecranon processes are reported to have been broken in one case observed by Mr. Fletcher;¹ the patient was a youth of sixteen, and it seems likely that the lesions might have been more correctly called epiphyseal separations. They were due to direct violence. Hamilton mentions having had occasion to reduce a backward dislocation (of nine weeks' standing) of the radius and ulna in a boy aged seven, in whom the olecranon, still, of course, an epiphysis, was separated by forcible flexion during the operation. He says further: "I have twice since broken the olecranon in attempts to reduce old dislocations of the radius and ulna backward, and I have not regretted the occurrence, since it enabled me to reduce the dislocations without cutting the triceps."

In most cases there is a perceptible gap between the detached portion and the rest of the bone, due in some measure at least to traction on the fragment by the triceps muscle; but there may be so much of the periosteum left intact as to prevent any separation. Cases do occur in which the fragment is drawn up along the back of the arm, but they are more rare than might be supposed. Flexion of the elbow increases the gap when one exists.

Tillaux² expresses the opinion that when there is separation of the fragments, it is due not to the drawing up of the upper one, but to the flexion of the elbow, removing the lower one; and cites in proof of this view the fact that the gap disappears when the elbow is again extended.

As soon as there is any separation at the point of juncture, the elbow-joint is of course opened, and, although the injury is subcutaneous, effusion takes place from the torn and irritated synovial membrane; a circumstance which, although it would not in itself suffice to push the fragments apart, certainly does not tend to diminish the gap.³

The *symptoms* of this injury are: immediate loss of the power of extending the forearm, and pain in the elbow on attempting to do so; some pain and soreness in the part, although this has not been marked in the cases I have seen; a cleft or gap between the fragments, filled up when wide by a soft, almost or quite painless, fluctuating swelling; generally there is also some bulging of the triceps muscle at its lower part, just above the seat of injury. Lonsdale⁴ quotes from Earle the case "of a gentleman who fractured the olecranon, and where the separation did not take place till the sixth day after the injury, at which period it was caused by the patient attempting to tie his neck-cloth." The detached portion can be grasped between the surgeon's thumb and finger, and moved by itself with more or less freedom. Crepitus is, of course, wanting unless the fragments are in contact; and the smaller the portion broken off, or, in other words, the nearer the fracture is to the summit of the process, the less likely is it that the surfaces can be rubbed upon one another. Ecchymosis is very commonly present, and may gradually extend along the ulnar margin of the forearm for several days.

These symptoms may vary considerably in distinctness, but they are, as a general rule, well enough marked to make the *diagnosis* clear. Bransby Cooper⁵ saw a case in which the power of extension of the forearm was so far retained as to give rise to much doubt.

¹ Med. Times and Gazette, Aug. 16, 1851.

² Anatomie Topographique, p. 578.

³ In this respect the olecranon differs from the patella, which is of less size as compared with the knee-joint. In fractures of the latter bone, it is held by some high authorities, that the separation of the fragments depends largely upon the free effusion of liquid into the articular cavity. But the patella clearly belongs among the "sesamoid" bones, while, according to Owen (Gray's Anatomy, p. 135, note), the olecranon is homologous with an extension of the upper end of the fibula above the knee-joint, which is met with in the Ornithorhynchus, Echidna, and some other animals.

⁴ Op. cit., p. 156.

⁵ A Treatise on Dislocations and Fractures of the Joints, by Sir Astley Cooper. Edition of 1842, p. 471.

Fractures of the olecranon are, for the most part, united by fibrous tissue only, the length of the band, as well as its thickness, varying in different cases. Yet there are many instances on record of true bony union; and this might be much oftener obtained, but for the difficulty of keeping the fragments in complete apposition. In Fletcher's case of fracture of both olecranons, before quoted, this result took place on each side, as proved by dissection after the patient's death nearly a year subsequently.

When osseous union occurs, there is on the outer aspect of the bone a deposit of callus, which gradually becomes absorbed; on the articular surface there is, as in other cases of fracture running into joints, a depression or groove marking the line of the fracture. In the case of ligamentous union, there are sometimes numerous bands passing from one fragment to the other, sometimes two or more at either side, and occasionally a thin membrane-like sheet, apparently derived from the periosteum.

A curious specimen exists in the Warren Museum,¹ of "a piece of bone broken from the olecranon, and fifteen years afterwards removed from the elbow-joint." It seems probable that this was a fragment from a comminuted fracture, torn away entirely from its fibrous connections, the remainder of the bone having become solidly united; but the account is not as full as it might be.

The difficulty often met with in maintaining the contact of the fragments, is due to several circumstances. One of these is the contraction of the triceps muscle, which, when the fibrous tissues surrounding the bone are torn through, must tend to draw the fragment up along the back of the arm, tilting it at the same time so as to widen the gap posteriorly. Another is the effusion which takes place in the joint, and which may be very copious. Still another is the upward traction not only of the triceps, but of the biceps and brachialis anticus (the latter especially), tending to crowd the end of the humerus between the fragments. All these belong especially to the early period, and vary in their degree in different cases. Sometimes the smaller fragment, drawn upwards, contracts adhesions in its new position, and thus, when swelling has subsided and muscular contraction has been quieted, may resist all efforts at bringing it down.

The result of experience is that the usefulness of the limb after a fracture of the olecranon is not dependent altogether upon the shortness of the band uniting the fragments. Even if union is effected by bone, there may be adhesions within the joint, or about it, limiting the movements of the forearm upon the arm. And, on the other hand, it sometimes happens that, although the separation of the fragments is considerable, the freedom and strength of the limb are but little impaired. In most of the ordinary functions of the hand, active extension of the elbow is less indispensable than flexion.

The analogy between fractures of the olecranon and those of the patella, in regard to the recovery of function even with a fibrous connection of some length, will be pointed out in connection with the account which will be given of the fractures of the latter bone.

Absorption of ligamentous union is recorded in one case by Mr. B. Cooper.² He says:—

"The patient should be cautioned against using his arm too freely, till the uniting ligament has acquired strength and firmness. A patient of Mr. Mayo's, whose olecranon had been fractured, and had united in six weeks by a ligament of the ordinary firmness, suffered severely from neglecting this precaution; for after using the arm as much as possible for some time, he found that it became weaker and weaker; the uniting liga-

¹ Catalogue, p. 171.

² Op. cit., p. 475, note.

ment was entirely absorbed, so that the fractured olecranon was drawn up by the triceps, the power of extending the elbow was almost lost, and the limb became wasted and useless."

The time required for the union, whether fibrous or bony, of a fractured olecranon, must vary somewhat, especially in the former case. About six weeks may be stated as the average period. When the fragments are united by bone, the strength of the limb is soon regained, and less caution is needed than if they are joined by fibrous tissue only. Such cases as that of Mr. Mayo, just quoted, are extremely rare; yet the stretching of newly-formed ligament may impair greatly a result which, if the tissue had time to gain strength, would be satisfactory.

Anchyllosis of the elbow-joint sometimes follows fracture of the olecranon, and the chance of its occurrence, although remote, is one which ought always to be borne in mind. Some degree of stiffening is very common, but usually disappears without special treatment; it depends upon the thickening and contraction of the fibrous tissues about the joint, as well as upon loss of tone in the muscles from want of exercise. When adhesions occur within the joint, they may be the result of inflammation due to the severity of the original injury; but there can be no doubt that they may be also occasioned by injudicious treatment, and that they are very apt to end in fixation of the parts. The means of avoiding this very unpleasant issue will be presently discussed.

The *treatment* of fracture of the olecranon consists in placing the arm in such a position as to facilitate bringing the fractured surfaces in contact, and confining it so until union shall have taken place. When there is very little separation the surgeon's task is simplified, as it is also by the absence of high inflammatory action in the joint. Yet it must be remembered that without the further advantage of proper care, stretching of the fibrous tissues connecting the fragments may take place, and the ultimate result be unsatisfactory.

For the first few days the arm should be laid in an easy position, with the elbow well extended, and means taken to allay any inflammation that may arise. I do not think that anything is gained by bringing the upper fragment down until all effusion into the joint has subsided; but, after this, the earlier and the more completely it is done the better. Of course, if no inflammation is set up, and the joint does not swell, there is no reason for waiting.

Modern surgeons are agreed that the best results are obtained by placing the forearm at a very obtuse angle with the arm, and keeping it so by means of an anterior splint. The splint should extend well up towards the shoulder, and far enough down to thoroughly control the forearm; I think it should go down into the palm of the hand, so as just to allow of flexion of the fingers. An ordinary roller, snugly applied, suffices to keep it in place. As to the material for the splint, it may be of wood, binders' board, or felt; tin, which answers very well when properly shaped and fitted, has the great advantage of not adding much to the bulk of the limb, and thus of allowing a loose sleeve to be slipped over it.

Some surgeons employ the plaster-of-Paris or starched bandage, but I cannot see that it is of any especial use in these cases. A skilfully applied roller will remain in perfect efficiency for three or four days, and the whole apparatus should be removed at least as often as this, for the purpose of ascertaining the condition of the parts.

Various devices have been employed or recommended for the purpose of preventing the retraction upward of the upper fragment in these cases. Figure-of-8 turns of a bandage, with or without the previous application of a compress, have often been used. Hervez de Chégoin¹ employed with success

¹ Am. Journal of the Med. Sciences, July, 1848; originally in the Gaz. des Hôpitaux.

an elastic compress, drawn downward by tapes attached to the lower end of a hollow, jointed splint.

Sir A. Cooper,¹ who advocated the straight position, advised that after bringing the fragment into apposition with the ulna, a piece of linen should be laid longitudinally on each side of the joint, and wetted rollers applied above and below the elbow; the extremities of the linen were then to be doubled down over the rollers, and tightly tied, so as to cause approximation. It is not distinctly said that he ever used this plan, which would seem to involve great discomfort at least to the patient, as well as risk of interference with the nutrition and innervation of the distal portion of the limb. This objection, indeed, holds good with regard to all the figure-of-8 and other bandages which encircle the limb; if tightly enough applied to be efficient, they may do harm.

With the excellent adhesive plaster now procurable, it is easy to keep the fragment in place without any such binding; a strip of suitable length and width being put on so that its middle shall press just above the fragment, while its ends are carried down along the ulnar side of the forearm, one in front and the other at the back, far enough to take a firm hold. The splint and bandage are then applied as before directed. A compress is needless, and might indeed do harm by tilting the fragment, so as to produce a condition such as Malgaigne quotes as seen by Pasquier: "the fragments, farther separated posteriorly than anteriorly, were only in contact by their anterior edge."

It has been suggested by myself,² as well as by others, that in cases of much difficulty an instrument analogous to Malgaigne's patella-hooks might be used—a small metallic plate or wire frame, with either one or two short recurved hooks, to be inserted into the posterior and upper part of the olecranon, drawn down, and fastened in place by means of a strip of adhesive plaster carried along the forearm, as before described. Such a contrivance could be readily made, and probably could be used without danger; yet I think that the majority of surgeons would be content with the results procurable by less formidable appliances.

Dieffenbach,³ many years ago, proposed and practised the division of the tendon of the triceps, bringing the upper fragment down into place, and occasionally rubbing the two fragments forcibly together; he claimed to have obtained firm union in this way.

Suturing the fragments has been proposed, and the operation has been performed in a number of instances. Mac Cormac⁴ and others have thus obtained bony union in cases attended with marked separation. Sheldon had already, in 1789, proposed the laying bare of the bone and rasping of the fractured surfaces, but says, in his work,⁵ that he never had attempted the operation. The introduction of the wire suture made the procedure far more effective, and the advocates of the so-called antiseptic system claim that their precautions make it safe. I must confess that no case has ever come under my own observation, in which it has seemed to me that the amount of advantage likely to be derived from such severe measures would warrant their substitution for the less brilliant methods above described. By care and accuracy in the adaptation and use of simple apparatus, satisfactory results can, as a general rule, be obtained.

¹ Op. cit., p. 474.

² New York Medical Journal, Dec. 1866.

³ Casper's Wochenschrift, 2 Oct., 1841.

⁴ Trans. of Clinical Society of London, vol. xiv., 1881.

⁵ An Essay on the Fracture of the Patella, or Knee-pan; containing a new and efficacious method of treating that accident: With Observations on the Fracture of the Olecranon. By John Sheldon. London, 1789.

Compound fracture of the olecranon is occasionally met with. Its gravity must depend, in a measure, upon the possible admission of air into the joint, or the effusion of blood into that cavity, either of which occurrences would be of serious import as to the prognosis and treatment of the case, by reason of the inflammation likely to ensue. When the synovial membrane remains intact, the wound must be closed, and the fracture dealt with as in ordinary cases; when the joint is laid open, it ought to be carefully cleansed with carbolized water, and all inflammation allayed by appropriate means before splints are applied. Anchylosis is very apt to ensue under such circumstances.

FRACTURE OF THE CORONOID PROCESS of the ulna is a lesion usually described as very rare, and it has certainly been very seldom recognized as occurring by itself. It may, however, be questioned whether it does not sometimes attend backward luxations of the forearm, as in a case reported by Sayre.¹

The first published observation of this lesion, according to Malgaigne, was that of Brassard, in 1811. The patient had fallen, three months previously, on his outstretched hand; the motions of the forearm were all free and painless, except flexion, which was limited. "In front of the ulna, between it and the end of the humerus, was found a hard body, somewhat movable, against which the ulna was arrested when the attempt to flex the forearm was made." Dorsey,² in 1813, says:—

"The coronoid process of the ulna, Dr. Physick has once seen broken. The symptoms resembled a dislocation of the humerus forward, or rather of the forearm backward, except that when the reduction was effected the dislocation was repeated, and by careful examination the crepitation was discovered."

Hulke³ mentions the case "of a man killed by a fall from the roof of St. George's Hospital, in whom the coronoid processes were found to be fractured, and the two bones of the forearm dislocated backward, on both sides." Bradford⁴ has reported the case of a man, aged twenty-four, who fell a distance of forty feet, and died of his injuries, among which was a fracture of the coronoid process of the ulna, part of the trochlea of the humerus being also chipped off. The main symptom is stated to have been constantly recurring dislocation backward. Sir Astley Cooper's two cases,⁵ one of which was verified by dissection, are well known. In the account of the latter, it is stated that the coronoid process "had been broken off within the joint," which is obviously an anatomical impossibility, although the fracture must of course have entered the joint. Another very often quoted case is that of Liston, in which a boy aged eight sustained the injury by hanging by his hand from the top of a high wall, afraid to drop down.

Fahnestock⁶ reported the case of a boy who "fell from the haymow, and received the whole weight of his body on the back part of the palm of the left hand, whilst the arm was extended forward, by which impulse the coronoid process of the ulna was displaced;" the limb presented the appearance of one in which the forearm was dislocated backward, but on being reduced the deformity recurred, and the recurrence was attended by an evident crepitation. It is stated that the boy "recovered very speedily," but the degree to which the power of flexion was restored is not noted. Duer⁷ saw a boy, aged six, who, seven weeks before, had fallen from a haymow and dislocated the forearm backward. The displacement still existed, "and the arm being somewhat flexed, the detached portion of the coronoid process lying in front of the

¹ Transactions of Med. Soc. of State of New York, 1871.

² Holmes's System of Surgery, 3d edit. vol. i. p. 162.

³ Boston Med. and Surg. Journal, July 17, 1883.

⁴ Am. Journal of the Med. Sciences, May, 1830.

⁵ Op. cit., vol. i. p. 152.

⁶ Op. cit., p. 469.

⁷ Ibid., Oct. 1863.

joint could be distinctly felt, and freely moved in any direction over a small space." Every effort at reduction failed, and the case was dismissed, pronation, supination, and extension being unimpaired. Gross¹ mentions a case reported to him by Dr. Scott, of Missouri, in which "the coronoid process formed a distinct prominence upon the anterior and inferior surface of the humerus, a short distance above the joint, movable from side to side, the olecranon being at the same time displaced slightly backward, and the forearm somewhat flexed. The accident was caused by a fall upon the hand while the forearm was forcibly extended." In Sayre's² case the fragment was adherent to the anterior surface of the (inner?) condyle of the humerus. He refers to a specimen of Dr. Darling's, showing this condition of things, and to another in which ligamentous union had occurred. The latter was obtained in the dissecting room, and was without history. Bryant mentions and figures a specimen in which the coronoid process and the anterior margin of the head of the radius were detached in an old woman by a fall; the fractures were compound, and amputation was performed.

From the foregoing quotations it will be at once perceived that the fracture in question may occur at almost any age, and has been ascribed to very various causes. I do not think it needful to discuss the correctness of the diagnosis in each case, as Hamilton has done, because the fact that the lesion occurs has been placed beyond doubt; and for practical purposes this is sufficient. Equally useless is the enumeration by Lotzbeck³ of twenty-four varieties of the injury. There can be no difficulty in understanding how, if the ulna is forcibly driven upward against the humerus, in any position, but especially in extension of the forearm, the coronoid process as a whole, or its tip only, may be split off. In the case of muscular action, as in the boy seen by Liston, the muscles arising from the inner side of the lower part of the humerus would pull the coronoid process backward against that bone, while the brachialis anticus would tend to drag it away from the body of the ulna. And a glance at a longitudinal section of the upper part of the ulna will show at what a disadvantage the cancellous structure of the base of the coronoid process would thus be placed, and how readily its separation might be brought about.

The cases of this fracture may be practically divided into two classes, according to the extent of the portion detached. If the tip only of the process is broken off, the fragment will be very small, and there will be no marked separation, except by the slipping backward of the ulna, and the consequent relative forward displacement of the humerus, limited by contact with the head of the radius. But when the whole of the coronoid process is split off from the ulna, the action of the brachialis anticus will serve to draw it upward, and the gap between the fractured surfaces will of necessity be more considerable.

Perhaps yet another division might be made, of those cases which are complicated by fractures of other bones in the neighborhood, as when the olecranon also is broken, or when, as in one of Sir A. Cooper's cases, the external condyle has been likewise separated. But here the fracture of the coronoid would as a general rule be the less important injury, and hence it would be more properly assigned the secondary place, as being itself a mere complication of the graver lesion.

The *symptoms* of fracture of the coronoid process have already been given incidentally. The power of flexing the elbow must be more or less seriously impaired; pain in attempting this motion, and tenderness in front of the

¹ Op. cit., p. 697.

² Loc. cit., p. 108.

³ Noticed in Schmidt's Jahrbücher, 1866.

joint, with occasionally the perceptible presence of the fragment, are to be looked for. Crepitus, if it exist at all, can be but slight. A tendency to luxation backward of the ulna may exist, but can hardly be marked unless some loosening of the attachments of the head of the radius has also occurred.

The *diagnosis* may sometimes be very obscure, and only to be arrived at by exclusion. Separation of the articulating portion of the lower epiphysis of the humerus might induce symptoms almost identical with those of this lesion, although in the former case it is probable that the interference with flexion alone would be less distinct.

The *treatment* of fracture of the coronoid process consists simply in flexing the forearm upon the arm, at an angle of about 90° or less, and securing it in this position by means of an anterior angular splint. Pressure should also be made upon the olecranon by applying the middle of a strip of adhesive plaster around it, and carrying the ends forward to be secured to the splint over the forearm; in this way the tendency to displacement of the forearm backward may be overcome with more certainty than by the turns of the bandage, which may slip and become loosened.

Especial care is to be taken in the treatment of cases in which the whole process is separated, as the action of the brachialis anticus will tend to draw the fragment up along the front of the arm, and permanent impairment of flexion must be expected. If the tip only is broken off, it will be subject to no such traction, and the fragment can only give trouble either by being entangled in the joint, or by adhering to the anterior face of the humerus just at its lower end. When the process is drawn up, it may be carefully coaxed down by the surgeon's fingers, and perhaps the pressure of the splint may keep it in place; or the forearm may be flexed at an acute angle so as to let the lower fragment follow the upper. Doubt must always exist, however, as to the efficiency of any treatment adopted, until the patient attempts to resume the use of the limb; and the prudent surgeon will be chary of giving assurances which the result may not justify.

FRACTURES OF THE HEAD OF THE RADIUS are very rare, unless along with other severe injuries of neighboring bones. Bryant's case has already been mentioned, in which the coronoid process of the ulna was also broken off. Malgaigne could only cite two cases, in both of which there was also fracture of the coronoid, and backward luxation of the elbow. The head of each radius was split longitudinally in Hulke's case of fracture of both coronoid processes, referred to on a previous page.

In the Warren Museum¹ there is a specimen (No. 1026) of "one-third of the head of the radius broken off, with a comminuted fracture of the upper extremity of the ulna," taken from a man who had fallen from the roof of a house. Another (No. 1031) is described as "longitudinal fracture of the head of the radius, with fracture of the ulna from the coronoid process downward;" and further as "a clear and regular split, involving very nearly one-half of the head of the radius, and cleaving outward so as to extend no further than the neck of the bone." Stimson² saw a fracture of the outer half of the head of the radius, produced by direct violence and followed by suppurative arthritis, in a boy aged thirteen; the excision of the joint enabled him to establish the diagnosis. Adams exhibited to the Pathological Society of London³ a specimen in which several fissures radiated from a point just below the head of the radius upward to the articulating surface; the injury was the result of a fall from a height.

¹ Catalogue, p. 172.

² Op. cit., p. 433.

³ Transactions, vol. xxii. 1871.

Other cases, followed by recovery, and hence open to some doubt, have been reported.

The *causes* of fracture of the head of the radius are those of similar injuries in the other bones of the same region; cases resulting from blows, falls, in which there is sometimes a doubt whether the violence has been direct or indirect, and railroad crushes, have thus been observed. In Hulke's case, affecting both arms, it can scarcely be doubted that there was indirect violence; in Bryant's, it is distinctly stated that the woman had a fall, striking on the elbow. But in either class of cases, the mechanism is readily enough explained.

As to the *symptoms*, they are by no means as clear as might be supposed, in view of the ease with which the head of the radius may be felt in the normal state. Pain, loss of power of rotating the hand, as well as of flexing the elbow, crepitus on passive motion, very rapid swelling, and synovitis of the elbow, are quite sure to occur; but the determination of the exact nature of the injury is not so simple a matter, especially in view of the fact that in so many of the recorded instances other lesions have also been present.

The *prognosis* of these cases must, of course, depend, in some measure, upon the amount of damage done to the joint, and to neighboring parts, as well as upon the success of efforts directed toward allaying inflammation. A considerable degree of stiffening may always be looked for, and this, in some cases, will be permanent.

As to the *treatment*, the first object must be to keep down inflammation in the joint, by the usual means, the forearm being semi-flexed. Nothing can be done in the way of correcting displacement, should such exist, which does not seem to have been the case in any of the recorded instances. The limb should be placed in the posture which affords the greatest ease, and lightly bound to a well-padded, angular splint. Passive motion should be attempted at about the tenth day, and repeated every twenty-four or forty-eight hours; the movements should be made with the utmost gentleness, but very thoroughly, and any irritation caused by them must be allowed to subside completely before the joint is again disturbed. If the irritation run very high, and last long, and if, on each successive occasion, it become more decided, the forearm must be bent at a right angle with the arm, in semipronation, in order to give the greatest use of the hand in case the stiffening becomes permanent.

FRACTURES OF THE ELBOW.—A few words may be said here in regard to these injuries, which comprise all those in which not only the lower end of the humerus, but one or both of the other bones entering into the joint are involved. They may be either simple or compound, and the extent of the lesion, whether of the bones or of the soft parts, may vary greatly. Sometimes the fragments are very much displaced, while, in other cases, they may remain almost undisturbed. Generally the cause is great direct violence, such as the passage of a wheel over the arm, or other crushing force.

When these fractures are compound, the position and extent of the wound of the skin will be influenced in some degree by the character of the cause. If the latter be direct violence, the wound may be at the back of the elbow; but if indirect, the skin being, as it were, burst open by the projection of the bone, the anterior surface of the arm just above the flexure is most frequently involved. In the former case, also, the wound is apt to be smaller than in the latter; although this, of course, is by no means a constant rule. Sometimes, although the fracture is compound, the joint is not laid open to the air, and this fact lessens the gravity of the injury.

Fractures of the elbow may occur to either sex, at any time of life; but,

for obvious reasons, adult males are most exposed to the causes of such injury.

The *diagnosis* is sometimes quite clear as to the nature of the hurt, but it may not be easy to determine exactly which bones are involved, and to what extent. Malgaigne mentions a case, as follows: "In the only example of comminuted fracture of the elbow which I have seen, the humerus was intact, except that its articular cartilage was stripped off; the patient had fallen from a second story upon the elbow, and the wound answered merely to a transverse fracture of the olecranon, leading me to think that this process alone was involved. The patient dying on the fifty-eighth day, the autopsy revealed a comminuted fracture of the coronoid process of the ulna, as well as of the head and neck of the radius."

When the external wound is large, exploration with the finger may afford much more exact information as to the precise nature of the damage to the bones.

There are very few injuries in which the *prognosis* is more doubtful than in those now under consideration. Every pathological cabinet contains specimens illustrating most extensive fractures involving the elbow, from which recovery has taken place, with deformity indeed, yet apparently with a fair degree of usefulness of the limb. In Malgaigne's case, just mentioned, there was an incessant oozing of blood from the fractured surfaces, which filled the joint, and doubtless had to do with the unfavorable result; such a complication might occur in any case, and disappoint hopes otherwise well founded. On the other hand, Sir A. Cooper¹ relates the case of a brewer's servant, in whom the elbow was crushed by the wheel of a dray, so that the finger could be passed through the joint, and the artery thus felt. He refused to submit to amputation, and recovered, with sufficient motion in the elbow to allow him to resume his former occupation. Another case is given by the same author, in which a man, aged seventy-four years, with very extensive fracture, made a complete recovery; "although the form of the joint was irregular, yet a considerable degree of motion was preserved."

I think it may be assumed that, in the latter case, the joint was not laid open—a circumstance which, as a general rule, renders the chance of a good result much greater. When this can be ascertained, the surgeon may, therefore, venture to give the patient much more encouragement than if the latter is likely to undergo the risk of a suppurative arthritis.

When the joint does not show any sign of stiffening, and especially if passive motion neither gives pain nor excites inflammation, the prospect is favorable, even if the outward shape of the part is disfigured—the result of several displacements being to give something like the natural mechanism. Much, however, depends upon the judgment with which passive motion is employed.

For the *treatment* of cases varying so widely in the degree and character of the lesions presented, it can scarcely be expected that definite rules should be laid down. When the fracture is a simple one, the course to be pursued is identical with that recommended when only one of the bones entering into the joint is concerned.

In compound fractures, if the joint be not laid open, the fragments must be adjusted, and any that are entirely loose removed; the wound is next to be closed as securely as possible, and the limb placed upon a rectangular splint; inflammation is to be expected, and must be met by fomentations, evaporating and anodyne lotions, or irrigation. Upon its subsidence, the same treatment should be instituted as for simple fractures, provision being made for the dressing of the wound until it has completely healed.

¹ Op. cit., p. 477.

When the joint is extensively laid open, or if the bones are very badly crushed, it may be good practice to excise the whole joint; a procedure which, although not mentioned by Malgaigne, has been resorted to with success in many instances, and is at present of recognized value. Sir A. Cooper cites two cases in which it was employed with excellent results by McIntyre, in one as early as 1829. I myself had at the Episcopal Hospital, a few years ago, a young man, who, by a fall from a roof, had sustained a very extensive compound fracture of the elbow; I freely excised the joint, and he recovered with so good an arm that he was able to resume his business as a tin-roofer.

When excision is decided upon, it is important to remember that much depends upon the removal of a sufficient amount of bone to leave the forearm freely movable; upon sparing muscular attachments as much as possible; and upon avoiding interference with vessels and nerve-trunks. Partial excisions have, in some instances, been done with success; but I think that the general result of experience is, that it is better to remove all the articulating surfaces, that healing thus takes place more quickly, and that to leave any portion of the joint adds nothing either to the safety of the procedure or to the subsequent usefulness of the limb.

Occasionally, besides the damage to the bones, the vessels are torn across, or such extreme injury has been inflicted on the soft parts as to be irreparable, and amputation must then be performed.

The question may be raised with regard to either amputation or excision, whether the better plan is to operate at once, or to wait until suppuration has been established; in other words, whether a primary or a secondary operation affords the best chance of a good result. I think it should be decided, not abstractly, but according to the circumstances of each case. If it is clear that operative interference must be resorted to, and the patient's condition does not forbid, there would seem to be no valid reason for postponing it. But if there is a doubt in the surgeon's mind, either as to the necessity of any operation, or as to which he should adopt, or if grave constitutional symptoms are present, a few days' delay may be of momentous advantage. Such questions, however, belong rather to general surgery than to the special branch now under consideration.

FRACTURES OF THE SHAFT OF THE ULNA are rare as the result of indirect violence, although Bellamy¹ has reported one in the upper third of the bone from a fall on the hand, in a child six years of age. Voisin is quoted by Malgaigne as having seen "a detachment of a longitudinal splinter from the articular facet" at the lower end, produced in the same way. Macleod has reported² a case seen by him in which the patient, in striking a blow, sustained a fracture of the styloid process of the ulna, with separation of the triangular cartilage. A more frequent cause is direct violence, as when a pugilist wards off a blow, and receives it on the edge of the forearm; or from a fall, striking the same part against a step or other resisting body. The ulna is subcutaneous in its whole length, and hence is specially exposed to injuries of the kind just referred to.

Labatt³ saw a healthy girl who had sustained a fracture of the lower third of the ulna by muscular action, as she was engaged in wringing clothes. A previous injury had impaired the power of supination.

In the statistics from the Children's Hospital, already quoted, in the 316 cases, the ulna by itself is said to have been fractured 11 times, or in very nearly $3\frac{1}{2}$ per cent. Yet the causes are much more prevalent among grown

¹ British Medical Journal, Sept. 16, 1876.

² Edinburgh Medical Journal, Nov. 1874.

³ Dublin Med. Press, April 8, 1840.

persons, and particularly in men, who, according to Malgaigne, contribute four-fifths of the subjects of this injury. Of the different portions of the bone, it would seem from the statistics given by Hamilton, as well as from those of Agnew, that the middle third is somewhat more frequently affected than either the upper or the lower; and the reason of this may be readily perceived.

In the Museum of the Pennsylvania Hospital there is a specimen¹ of double fracture of the ulna, the forearm having been bent around a revolving shaft. "The upper fracture is near the junction of the upper and middle thirds, and is somewhat oblique. The lower fracture is in the lower third, and is transverse. At the time of removal the fractures were not complete, the fibres of the bone which remained unbroken being much bent." The patient was a boy aged fifteen.

When the ulna is broken by direct violence, the fracturing force will obviously tend almost invariably to drive one or both of the fragments toward the radius, and thus to diminish the interosseous space. The upper fragment, from the nature of its connection with the humerus, is not as movable, laterally, as the lower, which is moreover acted upon, in some degree at least, by the pronator quadratus muscle. But the upper fragment may be tilted either forward or backward, as indeed the lower may be also; and thus will result a deformity and change of relation between the bones, by which, if uncorrected, the pronation and supination of the hand would be almost altogether prevented. For the production of this unfortunate effect, it is not necessary that either fragment should be very markedly displaced; a very slight change of angle is sufficient to destroy the parallelism of the two bones, and thus to impair the efficiency of their mechanism.

Hamilton says that there is no other long bone the fractures of which are so often complicated as are those of the ulna; and Agnew makes nearly the same statement. The former author saw, in 12 cases out of 36, the radius dislocated forward, or forward and outward, and in one a backward luxation of both radius and ulna, while in four cases the fracture was compound. The rationale of the displacement of the head of the radius, after the support of the sound ulna is lost, is not difficult to comprehend.

A curious specimen exists in the Warren Museum,² which has been already noticed on account of the lesion of the radius; that of the ulna is thus described: "The fracture of the shaft of the ulna is very oblique, commencing at the depression of the articular surface, marking the separation of the coronoid process and the olecranon, extending almost longitudinally $3\frac{1}{4}$ inches downward, and detaching from the shaft that portion of the bone to which the olecranon was attached." A somewhat similar case, but extending downward only two inches, and followed by non-union, was reported by Brainard.³ Very generally the fractures of the ulna present but a slight degree of obliquity.

The *symptoms* are pain and loss of power in the forearm and hand, swelling, ecchymosis, and tenderness at the seat of fracture. Sometimes the fingers of the surgeon, passed along the edge of the forearm, perceive a depression or angle, and crepitus is elicited on pressure. Occasionally, in order to develop this latter sign, it is necessary to grasp the upper and lower portions of the forearm, and make a slight effort as if to rotate the lower upon the upper. Care must be taken, however, to avoid any manipulation which might cause displacement, or increase it if it already exists.

The *diagnosis* is not often difficult, the subcutaneous position of the bone giving a fair opportunity for its thorough examination. The possibility of

¹ Catalogue, p. 23, No. 1095.

² Catalogue, p. 173, No. 1031.

³ Transactions of the Am. Med. Association, vol. vii. 1854.

complications should not be lost sight of; the surgeon should see, for example, that the head of the radius is in its proper place.

Union generally takes place readily, but a number of cases of false joint have been observed in this bone, perhaps on account of rotary motion communicated to the lower fragment through too great liberty allowed to the hand, or it may be by the entanglement of a torn edge of the interosseous membrane between the fragments.

Callender¹ has recorded a case in which the styloid process of the ulna, carrying with it the triangular ligament (?), was torn off, and in which, when the parts were examined, the ulnar nerve was found wedged between the two portions of bone.

The treatment may be a very simple matter, or may present considerable difficulties. The first point is to correct any displacement that may exist; and the only direction that can be given for this is, that such manipulation is to be employed as may in each case be found most effectual. Sometimes the bone is brought into perfect line by merely pressing the soft parts into the interosseous spaces, anteriorly and posteriorly; and this should always be done, although it may also be requisite to correct an angle forward or backward, as well as to make some extension in order to disengage the fragments from one another, or from the torn interosseous ligament.

As a general rule, the semi-prone position (with the thumb upward), is the best; and if the patient is either a child or a restless or unruly adult, a splint extending from the middle of the upper arm to the ends of the fingers, with a right angle corresponding with the elbow, will serve to secure it. My own preference is for two small slips of wood, well-padded, and applied along the dorsal and palmar surfaces of the forearm, with very careful bandaging from the tips of the fingers to the elbow; a piece of binder's board, cut so as to form an internal, angular splint, reaching down to the ends of the fingers, and with the forearm part broad, so that its lower edge can be turned up to support the whole ulnar side of the limb, may then be softened in hot water, moulded to the arm, and secured by a roller. For the first few days the condition of the fingers should be carefully watched, lest the circulation be interfered with by the compression; a number of cases are on record in which neglect in this respect has cost the patients the loss of their arms, and even of their lives.

Some surgeons are content with a mere trough, in which the semi-prone forearm is laid, and confined by means of a bandage; but there can be no question that more efficient confinement is needed in many cases, and is safer in all.

In *compound fractures of the ulna* the treatment must be essentially the same, although a gap should be left opposite the wound to allow of its being dressed.

When the trough or angular splint is properly applied, the sling can hardly do any harm by pressing one or both fragments toward the radius; but it is better to have it of ample width. The hand should never be allowed to hang free, but should be well supported by the angular splint. When the apparatus is removed for the purpose of examining the limb, the utmost care should be taken to guard against any sudden displacement. I think it may even be better to leave the small splints in place for a week or two, and merely to ascertain by passing the fingers along the bone that the fragments are in their proper relation.

Passive motion is in these cases wholly unnecessary, and would be very likely to do harm. At the end of about four weeks, the arm-part of the sup-

¹ St. Bartholomew's Hospital Reports, 1870.

porting splint may be left off, and in a week more the hand may be set at liberty; next the small splints may be removed, and then the apparatus may be permitted to become loose, and so worn for a few days, when it may be finally dispensed with.

Pseudarthrosis, when it occurs in the ulna, is not easy to deal with on account of the presence of the radius. Of sixteen cases collected by Muhlenberg,¹ five were treated successfully by drilling, and in one the plan failed; four by resection, with one success, two failures, and the result in one not stated; three by frictions, with two successes and one failure; one successfully by tincture of iodine applied to the skin; another by scraping the periosteum subcutaneously; and another by mere mechanical pressure. From this it would appear that the methods which do not involve much disturbance of the parts are, in the case of this bone, the most effective.

I may add that Le Fort² has recently recorded a case in which he succeeded in obtaining union by means of electricity.

Malgaigne quotes from Bérard a case of comminuted fracture of the lower fourth of the ulna, with division, not only of the muscles, but of the ulnar artery and nerve; he tied both ends of the artery, dressed the wound, placed the forearm first upon cushions and afterward in the ordinary apparatus for fracture of both bones, and succeeded in obtaining, at the end of sixty-eight days, complete consolidation and cicatrization.

FRACTURES OF THE RADIUS alone constitute a very large proportion of the whole number of fractures, not only of the upper extremity, but of the skeleton in general. But this is due to the frequency with which the bone gives way at its lower part, close to the wrist; the other portions of it are much more rarely broken. In illustration of this statement, I may quote the figures given by Agnew,³ derived from the registers of the Pennsylvania Hospital. Out of 648 fully recorded cases, 24, nearly 4 per cent., were in the upper third of the bone; 53, a little over 8 per cent., in the middle third; and 571, about 88 per cent., in the lower. Hamilton's observations present a curious agreement with these; out of 101 cases, 3 were in the upper third of the bone, 6 in the middle third, and 92 in the lower.

Fractures in the *upper third* of the bone are generally, I think, the result of direct violence. But in 1856 I saw a case under the care of Dr. Miltonberger, in Baltimore, in which the radius had given way very high up as the patient was pulling very hard in driving a pair of horses. I do not know of any other recorded case of the kind, but the history of this one was clear, and the mechanism may be easily perceived; the twist impressed upon the bone by the action of the biceps was such as to overcome the strength of the tissue.

Fracture of the *neck of the radius*, properly so called, may take place from direct violence, as in some cases of crushing of the elbow; although I think this bone is more apt to escape by reason of its mobility and small size. But no instance is known to me in which it has been ascertained to be broken by itself. The specimen in the Mütter Museum, which has been sometimes said to illustrate this lesion, is, in fact, one of fracture through the tubercle, and the displacement is such as to show the action of the biceps upon the upper as well as upon the lower fragment; it is without history, which is much to be regretted. Moore⁴ has reported a case in which the separation was clearly high up in the shaft, and not in the neck itself; and he refers to another, observed by Parker, where there was luxation of the head of the bone, which

¹ Agnew, op. cit., vol. i. pp. 768, 769, 770, 806.

² Bull. et Mém. de la Société de Chirurgie de Paris, 1882.

³ Op. cit., vol. i. p. 901.

⁴ London Med. Gazette, Oct. 17, 1845.

"was drawn considerably above the elbow-joint, by the contraction of the biceps muscle;" reduction was accomplished, and the case is said to have done well.

In speaking of the relative frequency of fractures in different portions of the radius, it will be remembered that I quoted statistics from Agnew and Hamilton, in which the bone was considered as divided into an upper, middle, and lower third. I venture to suggest that it would be better for practical purposes to study these injuries according as they affect the shaft of the bone above or below the insertion of the pronator teres, leaving fractures at or close to its lower extremity in a separate class. For there is no portion of the skeleton in the fractures of which the influence of muscular action upon the production or maintenance of displacement is more distinctly traceable than it is in those of the shaft of the radius.

The great function of this bone is pronation and supination, as may be clearly seen by a glance at the muscles which act upon it. One of these, the biceps, is indeed a flexor, but it is a supinator also. The supinator brevis acts upon the upper portion—almost, if not quite, half of the bone—the supinator longus upon its lower end. The pronator teres is inserted into about an inch of its outer edge at its mid-length, while the pronator quadratus acts in a supplementary way on the lower portion of the shaft.

If now the shaft gives way between the tubercle and the insertion of the pronator teres, it must be obvious that while this muscle will tend to rotate the lower fragment into pronation, and to drag it toward the ulna, the upper fragment will be rolled outward by the supinator brevis and biceps, the latter also tilting it up forward. The action of the supinator longus in opposition to the pronator teres will amount to nothing as soon as the continuity of the bone is lost; and the pronator quadratus will simply, by the contraction of its upper fibres, pull the lower fragment toward the ulna.

If, on the other hand, the shaft is broken below the insertion of the pronator teres, this muscle will draw the upper fragment toward the ulna, but its rotating action will be opposed by the supinator brevis and biceps; the pronator quadratus will act in the same manner as before, but more strongly, as the fragment will be shorter. Here the displacement produced will be an angle salient toward the ulna, while in the former case there will be added a rotation outward, as well as a tilting up forward, of the upper fragment. Clinical observation, as well as the testimony of museum specimens, will be found to support these statements, the practical bearing of which will presently further appear.

Malgaigne gives some curious facts as to the distribution of these fractures between the sexes. He found the radius broken in ninety-five males, and in sixty-five females;¹ but this proportion, three to two, was not maintained at all ages.

"The number of male cases to females is ten to one in infancy; between fifteen and twenty it is fifteen to one. Thus up to twenty years of age this fracture is almost exclusively masculine. From twenty to forty-five, it affects women in pretty large numbers; twenty-two, in a total of seventy-two. But, after forty-five, another change occurs, and the fracture displays a marked preference for the female sex; there being but twenty men to forty-one women."

As to the *causes* of these fractures, they would seem to be sometimes direct violence, sometimes falls on the hand. Malgaigne quotes from Van N  rop the case of a woman, aged thirty, who, after wringing out two large sheets, felt sharp pain in the forearm, when a fracture in the lower third of the

¹ These figures include all fractures of the radius—not those of the shaft of the bone only, but those of its lower extremity also.

radius was detected. O'Brien¹ reports that he saw an oblique fracture of the bone, about three inches above the wrist, produced by muscular effort in aiding to lift a large cask. It is not improbable that cases of this kind are more frequent than would be supposed from the scantiness of the records.

Prominent among the *symptoms* of fracture of the shaft of the radius is always loss of power in the hand; although the patient may still be able to flex the fingers, and perhaps to pull or lift in some degree. But from what was before said as to the function of the radius, and the action of muscles upon it, it must be clear that the breaking of this bone cannot fail to render the hand useless, for want of pronation and supination. Deformity is usually present, the forearm having a curiously twisted look; and if the hand is grasped and rotated, there is an odd sense of looseness in the limb, the patient experiences pain, and, unless the fragments are separated altogether, there is crepitus. I have never myself seen a case in which the latter symptom was wanting. The injured part quickly swells, and the other phenomena become much obscured.

In examining a forearm for the detection of this or any other fracture, the best procedure is for the surgeon, after noting the position in which the limb lies, to grasp the hand with his corresponding hand, and bring it into semi-pronation; then to run the fingers of his other hand along the ulna, with some pressure, so as to determine the soundness of that bone. Next, applying his disengaged hand gently but closely to the upper part of the forearm, he rotates the patient's hand, with slight extension; the fragments will usually be felt to rotate upon one another, and at one point the movement will cause pain. Greater certainty is given to this manœuvre, if the thumb of the surgeon is applied to the head of the radius, which may often be felt not to follow the motion of the hand as it normally should. The precise point of fracture may be determined by passing one or two fingers lightly but firmly along the bone; a certain yielding, with crepitus, will be felt when the spot is reached, and the patient will experience pain. When the fracture is below the mid-point of the bone, it can be much more readily perceived than above, where the examination must be made through a greater or less thickness of muscular tissue.

When the symptoms are ordinarily distinct, there can be little or no difficulty in the *diagnosis*; but it may readily be imagined that if the periosteum should be untorn, and the fragments be thus held in contact, the fact of fracture might escape detection. Serious displacement would not under such circumstances be likely to ensue; and especially if, notwithstanding the absence of conclusive symptoms, the case were treated as one of fracture.

I may mention that the rotation of the radius in an uninjured arm sometimes gives rise to a sound somewhat resembling crepitus, either by contact of the head of the bone with the condyle of the humerus, or by friction of the tendons in their sheaths. Any error thus induced would, however, be on the safe side.

From what has already been said, it will be perceived that the result of fracture of the shaft of the radius, if left to itself, would be likely to be the loss of much of the usefulness of the hand. If the bone were broken above the insertion of the pronator teres, the upper fragment would be supinated, and the lower pronated; the upper would be tilted forward, and the lower drawn inward toward the ulna. If the fracture were below that point, the upper fragment might be but little rotated, but the lower would be drawn away from it, and from its shortness even more strongly pulled toward the ulna. And in either case the displacement of the upper end of the lower fragment would be favored at least by the action of the supinator longus muscle; of this a

¹ Atlanta Med. Register, 1881.

striking illustration is given by Malgaigne.¹ He says, "the styloid process has been drawn up to the level of that of the ulna, than which it is notably lower in the normal state of things." How this was done, he does not say; but it seems to me to be best explained by the action of the supinator longus.

In *treating* these injuries, two objects are to be especially aimed at: to place and keep the fragments in their normal relation as to their axes, and to maintain the inter-osseous space. Lonsdale, long ago, urged the importance of the former point, but I think that some later writers have in great measure lost sight of his views, and have given attention too exclusively to keeping the two bones apart.

Perhaps it is not making too sweeping a statement to say, that in all fractures above the middle of the bone the forearm should be supinated, while in all below that point the semiprone posture is preferable. For in the former case we want, to use Lonsdale's words, "to place the hand and forearm in such a position, that the lower portion of the bone may be supinated to the same extent as the upper;" but in the latter the condition of supination of the upper fragment does not exist.

In any fracture of the radius, then, above the insertion of the pronator teres, I should advise the use of an anterior angular splint of wood, carefully padded; and on the dorsal (in this case the lower) surface of the forearm I should place a narrow slip of wood, padded so as to act as a compress to fill up and maintain the interosseous space. The angle of the splint may be about 90° , or a little less if the upper fragment of the bone tends to be strongly tilted up. If the action of the supinator longus muscle, drawing the styloid process of the radius upward, toward the elbow, be very marked, it may be well to apply slight but steady extension of the hand toward the ulnar side; means of doing this will readily suggest themselves. The best plan in my opinion would be to put on the hand a glove, with the fingers removed, and with tapes sewed to it by means of which it could be tied to the corner of the splint; or they could be brought up over a notch at that point, to be fastened on the upper surface of the board. To make this dressing effective, the lower part of the forearm, just above the wrist, must be steadied on the ulnar side; which may be done by means of a wide loop of adhesive plaster, both ends of which may be brought to the outside of the splint, on its upper or palmar surface, and there fastened.

When the radius is broken below the insertion of the pronator teres, the best appliance is an internal angular splint reaching from the upper part of the arm to the ends of the fingers, and with the part corresponding to the hand so shaped as to draw the hand somewhat strongly downward, or toward the ulnar side. The forearm-part of this splint should be carefully and firmly padded along the middle, especially toward the wrist; and a similarly padded dorsal splint, but much narrower, should be laid along the back of the forearm.

Before applying the splints in any case, the fragments should be carefully restored to their normal relation, and so held until the dressing is complete. The bandaging should be done with the utmost care, snugly, but not tightly; and the surgeon will do well to remember that he is dealing with a part in which gangrene has repeatedly been induced by neglect or want of skill in applying apparatus. Frequent inspections should be made, and the state of the circulation in the fingers watched; upon the slightest appearance of congestion, or complaint of undue pressure, the limb should be stripped and the dressing reapplied, with such modification as may seem to be demanded.

Within three or four days it may be expected that the swelling will sub-

¹ Atlas, Pl. IX. Fig. 5. Translation, Fig. 50.

side, and that the bandages will become inefficient; but in removing them care should be taken not to allow of any displacement of the broken bone.

Compound fractures of the radius in its shaft may of course occur; but I do not remember to have ever seen one, except from gunshot wound, and there are no special points which require comment in regard to the phenomena or treatment of such a case.

FRACTURES OF THE LOWER PORTION OF THE RADIUS are among the most common of accidents, and must always have been so; yet it was not until the present century that they were distinctly recognized and accurately described. The history of the development of our present knowledge of these injuries is so curious as to merit some notice.

Pouteau¹ had thrown out the idea that fractures of the radius in the vicinity of the wrist, caused by falls on the hand, were "generally mistaken for sprains, for incomplete luxations, or for separations between the ulna and radius;" but the statement seems to have attracted no attention at the time. The same view was promulgated by Desault;² but to Colles,³ of Dublin, is due the credit of having given the first clear and practical account of these injuries and of their distinctive features. Dupuytren,⁴ Goyrand,⁵ Diday,⁶ and Voillemier,⁷ realized the importance of the fracture in question, although none of them seem to have been aware of Colles's paper; and the same may be said of Nélaton and Malgaigne. Even Sir Astley Cooper makes no mention of Colles's name, and Fergusson barely alludes to his having written on the subject. In fact, this first real investigator of the matter would seem to have been forgotten until Prof. R. W. Smith of Dublin, in his very valuable work,⁸ accorded him the credit to which he was so justly entitled. At present, the name "Colles's fracture" is generally recognized by surgical writers, and employed to designate fractures of the radius close to the wrist, even if not corresponding exactly to the description which Colles gave. Prof. Gordon, of Belfast, has published⁹ some researches which have shed further light upon the mechanism of these fractures, as well as upon their treatment; his views have found confirmation in some interesting cases recorded by Cameron, of Glasgow.¹⁰

In the United States, attention was first drawn to the subject by Dr. John Rhea Barton,¹¹ of Philadelphia; his views were based upon clinical observation only, and not upon anatomical facts, yet they were ingenious and well stated, and found extensive acceptance among the surgeons of this country.

After this, no separate original American paper on this topic appeared for over thirty years, until Prof. Moore,¹² of Rochester, advanced the opinion that the fracture of the radius was a less important lesion than the luxation of the lower end of the ulna, which certainly is often a marked feature of these cases, and suggested a plan of treatment based upon this view.

¹ Œuvres Posthumes, tome ii. p. 251. Paris, 1783.

² Œuvres Chirurgicales, tome i. p. 155. Paris, 1813.

³ Edinburgh Med. and Surg. Journal, April, 1814.

⁴ Leçons Orales, tome iv. p. 161. Paris, 1834. See also the volume "On the Injuries and Diseases of Bones" (Sydenham Society, 1847), which consists of selections from the above-named work.

⁵ Gazette Médicale, 1832, and Journal Hebdomadaire, 1836.

⁶ Arch. Gén. de Médecine, 1837.

⁷ Ibid. 1842; article republished in his Clinique Chirurgicale, Paris, 1862.

⁸ A Treatise on Fractures in the Vicinity of Joints, etc. Dublin and New York, 1854. (The preface to this work is dated 1847.)

⁹ A Treatise on Fractures of the Lower End of the Radius, etc. London, 1875.

¹⁰ Glasgow Med. Journal, March, 1878.

¹¹ Med. Examiner, 1838.

¹² Transactions of the Med. Society of the State of New York, 1870.

Another essay which has attracted much attention, and which has shed additional light upon the mechanism and pathology of these lesions, has been published by Pilcher,¹ of Brooklyn. I may perhaps mention also a paper of my own, read before the surgical section of the American Medical Association, in 1878,² the views contained in which will be presented, together with those of the authors previously named, in the following pages.³

The brief sketch now given is that of a very great and important change in professional opinion. Luxations of the wrist, which were formerly supposed to be of very common occurrence, and described in detail, in at least four varieties, have been relegated to a place among the rarest lesions; while fractures of the lower portion of the radius are recognized as of extreme frequency.

A careful study of the shape of the bone will render the study of its fractures much easier. In speaking of it, it will be supposed that the hand is hanging by the side, with the palm looking forward, so that the anterior surface is the palmar and the posterior the dorsal, that the inner edge is the ulnar, and that the carpal articulating surface is downward. Adduction is bending the wrist so as to bring the hand toward the median line, or the side of the little finger, abduction bringing it toward the outer or thumb-side; in the former case, the angle on the ulnar side, between the hand and forearm, and in the latter, that on the radial side, is rendered more acute. Points to be noted are the projection of the radial styloid process, and the fact that it is normally at a lower level than that of the ulna; the sudden swell of the bone downward, just above the joint, so that there is an enlarged portion, as compared with the shaft, somewhat irregularly cubical in shape; and the forward curve of the anterior wall of the bone, making a decided concavity in its outline if looked at from either side. This conformation is sometimes more and sometimes less marked. The fact that the most frequent *cause* of fracture of the radius, low down, is falling on the palm of the hand, may readily be seen to explain its comparative infrequency in childhood, as the weight is smaller and the leverage less than in similar accidents in the adult. In youth, epiphyseal separations, although not often met with, are not unknown; and at all later periods of life the bone gives way with great readiness.

Both sexes are alike liable to these injuries.

As already said, in a vast majority of the cases the cause is a fall on the palm of the hand; in a few, however, the back of the hand comes to the ground, and the difference in the effect produced is of no small importance, as I shall try to show hereafter. Direct violence is, I think, still more rarely assignable as a cause; Malgaigne quotes one case from Hublier, in which a young girl, whose wrist had been caught between a carriage-pole and a wall, had a transverse fracture of the lower part of the radius, the lower fragment being also split vertically into two parts.

Authors have expressed very divergent views as to the lines of these fractures. Without quoting these at length, I may merely say that the practical result of the examination of cases and specimens seems to me to be that the lines of breakage are almost infinitely various. Sometimes the bone gives way almost exactly transversely, the fragments being, however, serrated or notched; sometimes the fracture is oblique from before backward, or from within outward, or part of it may run in one direction and part in another. Sometimes the separation takes place very close to the joint, sometimes farther from it.

¹ Transactions of the Med. Society of the County of Kings, March, 1878.

² Published in the Am. Journal of the Med. Sciences, Jan. 1879.

³ The reader will of course understand that the above list is not intended to embrace all that has been written on the subject, which has been of course dealt with in systematic works, as well as in short articles containing reports of cases, suggestions in regard to treatment, etc.

Sometimes the lower fragment is split or fissured in various directions, so as to constitute two or more fragments of very irregular size and shape. Occasionally the fracture begins at the articular surface, and runs up into the substance of the bone to a greater or less distance; of this a notable example exists in the Warren Museum,¹ and another is mentioned by Dupuytren.² In another specimen³ in the Warren Museum, there is a double fracture, the result of direct violence; it is described as "comminuted fracture of the lower end of the radius, just above, and into the joint, and a second fracture, two and a half inches above the joint." Dupuytren⁴ records another case, in which a woman, aged sixty-two, having rolled down about sixty steps, had "one fracture about an inch above the joint, and the other an inch and a half higher up. The ulna, which was dislocated inward, protruded to the extent of more than an inch through the skin."⁵ The Museum of the New York Hospital contains a specimen⁶ described as a fracture of the lower end of the radius "obliquely upward and backward, from within a quarter of an inch of the palmar edge of the carpal joint. The fracture was transverse and incomplete; for a long narrow fragment passing up from the styloid process was still continuous with the shaft. This connecting bony bridge was slightly bent so as to permit the articular surface of the radius to be slightly rotated toward the dorsal surface of the forearm." In the other forearm there was extensive comminution of the radius for the space of two inches, and the shaft "is seen to be invaded by a longitudinal fissure running up from the fractured surface."

Occasionally there is a separation of a lateral portion of the articular extremity. A number of instances are on record in which the styloid process has been thus broken off. Such a specimen exists in the Wistar and Horner Museum, and another in the Warren Museum;⁷ Callender⁸ speaks of two in museums in London, and Hamilton thinks that he has made out the lesion twice in the living subject. One curious case is recorded by Butler,⁹ in which a boy of fourteen, by a fall from a height of thirty feet, had the styloid process broken off and drawn upward an inch and a half, where it became firmly united.

In the New York Hospital Museum there is a specimen¹⁰ in which "the only fracture of the radius consists in a chipping off of a small portion of the lower extremity, so as to separate the articular facet for the ulna from the rest of the bone. One of the carpal bones is also broken." It is difficult to entertain any other theory of the mechanism of this lesion than that of direct violence.

Gross¹¹ records the following: "In the case of a young man whom I attended along with Dr. Chenowith, the lower extremity of the radius was split in two by a transverse and an oblique fissure, the larger fragment being

¹ Catalogue, p. 174, No. 1035.

² Injuries and Diseases of Bones, p. 126.

³ Catalogue, p. 174, No. 1038.

⁴ Op. cit., p. 127.

⁵ I am tempted to refer here to an instance reported by Mr. Godlee (Med. Times and Gazette, 1883), in which a man, aged twenty, by a fall backward on his hands, sustained a compound fracture of the left radius at the junction of the middle and lower thirds, with displacement forward of the lower end of the ulna, which projected beneath the skin. "An incision was made, and the tendon of the flexor carpi ulnaris, which had slipped behind the bone, was raised up with a blunt hook; but the ulna could not be replaced until first the styloid process and then the end of the bone had been sawed off." The mechanism of this injury seems to me to have been clearly the same as that in Dupuytren's case above mentioned, in which the removal of the end of the ulna was also practised, but not with so complete a restoration of the functions of the limb.

⁶ Catalogue, p. 80, No. 130.

⁷ No. 4631. (Mentioned in a letter from Dr. Hodges.)

⁸ St. Bartholomew's Hospital Reports, 1865.

⁹ New York Medical Journal, 1867.

¹⁰ Catalogue, p. 79, No. 128.

¹¹ Op. cit., vol. i. p. 970.

completely detached and thrown inward and forward over the ulna, whence, as it was impossible to replace it, I removed it by incision. A good recovery took place, with hardly any impairment of the functions of the wrist-joint."

From what has been said, it is evident that the widest variety has been observed in the lines of breakage in the neighborhood of the wrist. Yet it is none the less true that in the vast majority of cases the lower end of the radius is fractured in a direction more or less transverse, and that the deformity produced is nearly the same in all.

Mention has already been made of the fracture theoretically described by Barton; and as his paper, the first one published on this special subject in America, had for a time a good deal of influence on professional opinion, it may be well to explain briefly what his views were. He says that in the act of falling "the hand is instinctively thrown out, and the force of the fall is first met by the palm of the hand, which is violently bent backward until the bones of the wrist are driven against the dorsal edge of the articulating surface of the radius, which, being unable to resist, gives way. A fragment is thus broken off from the margin of the articular surface of this bone, and is carried up before the carpal bones and rested upon the dorsal surface of the radius; they having been forced from their position either by the violence or by the contraction of the muscles alone." Again, he says: "It sometimes happens, also, though rarely, that fracture of a similar character to the one first described occurs *on the palmar side* of the radius, from the application of force against the back of the hand while it is bent forward to its ultimate degree."

In the forty-five years which have elapsed since the publication of these views, there has not been, as far as I have been able to ascertain, a single instance placed on record in which they have been confirmed by dissection. Voillemier¹ quotes one case from Lenoir, which may have been of this character, but is open to doubt; and in most cases of comminution of the lower fragment, the dorsal portion has been broken off. But although a detached piece might be carried up before the carpal bones, there would not be, as he says, "on the palmar side a prominence which is round and smooth, and differing in this from similar projections formed by the fractured ends of bones." Nor is it likely that, from a fracture merely of the posterior lip of the articulating surface of the radius, treated with ordinary skill or care, such bad results would often ensue as Barton enumerates: "A crooked arm, deformities, rigid joints, inflexible fingers, loss of the pronating and supinating motions." Yet consequences like these are frequently seen to follow the fractures just above the wrist.

Fractures presenting such various conditions must, of course, be due to equally various mechanisms. Nevertheless, the vast majority of cases must be ascribed, I think, to the "cross-breaking strain" produced by over-extension of the wrist, as maintained by Callender, Gordon, and Pilcher. In other words, the hand being forced backward, an immense tension is put upon the anterior carpal ligament, and thus a leverage is exerted upon the lower end of the bone, beyond the resisting power of its structure. First the palmar wall gives way, then the columns or lamellæ in succession, and finally, the dorsal wall.

When the fall takes place on the back of the hand, the bone gives way in like manner, but in a reverse direction; the mechanism is the same. That

¹ Archives Générales de Médecine, Déc. 1839.

this occurs, I think there is ample evidence, although it has been doubted by some writers.

Fractures of the lateral margins of the articulating surface are less easily explained, but may be due to the sudden force brought to bear by violent contact of the carpal bones, and the same may be said of the rare instances of "stellate cracks."

Upon the occurrence of transverse fracture in the way above stated, the area of the end of the upper fragment is less than that of the opposed surface of the lower; and the force continuing to act, the former is driven down into the cancellous tissue of the latter, and may split or burst it into several lesser fragments, thus comminuting it. Or, if this splitting does not take place, the compact wall may penetrate the spongy texture of the lower fragment, constituting an impaction. Experiments on the dead subject have been many times made by different observers, and always with the same general result, in support of the above statements.

With regard to the occurrence of impaction, writers have been greatly at variance. Gordon says that in Colles's fracture it is impossible. Callender says that thirty-six specimens in the various museums in London show deformity in all clearly due to "the impaction of the proximal into the distal end of the bone." Voillemier thought the impaction so marked a feature of the injury that he would rank it among what he calls "fractures by penetration." R. W. Smith argues that the appearances which led Voillemier to this opinion were due to deposits of new bone. This question seems to me to have been discussed at greater length and with more zeal than its importance really warrants. It cannot be settled upon the evidence of specimens of old and long-healed fractures alone, but lesions of recent date must be examined also; and from both together I think the conclusion is unavoidable that impaction occurs in some cases, while in others it is wanting. Deposits of new bone may undoubtedly take place in some cases, simulating impaction, or increasing its apparent extent.

Probably the experience of most surgeons will confirm the statement of Pilcher, that a fall on the palm of the hand may be productive of a mere strain of the ligamentous structures, of bruising or even of fissuring of the bone, or of actual fracture with separation, according to the grade of the force brought to bear in over-extension of the hand.

The *symptoms* of this fracture are, as a general rule, very decided. There is great pain, and instant helplessness of the hand; the wrist is almost always deformed in a marked degree, and often both preternatural mobility and crepitus are present. Swelling comes on very rapidly, and, in some cases, there is ecchymosis, although, by reason of the thickness of the skin of the palm, this is not as apt to occur as in fractures in most other regions.

The deformity requires special mention. It is such as might be expected from the bending backward of the lower extremity of the radius; the back of the wrist is humped up, and there is a corresponding depression at the palmar side, with a sort of creasing of the skin. Sometimes the dorsal prominence is distinctly greater at the radial side, the part having a twisted appearance. By Velpeau the deformity was said to resemble the back of a silver fork, and the comparison is not an inapt one. Taken together with the pain and loss of power in the hand, it is often in itself conclusive as to the nature of the injury.

Preternatural mobility may usually be detected by grasping the patient's hand (as if in shaking hands), and taking hold of the forearm; then flexing and extending the wrist. By the same manœuvre crepitus is apt to be elicited, but it may be very slight. In the case of decided impaction, both of these symptoms may be but slightly marked; when they are very readily

perceived, there is reason to suspect comminution. Maisonneuve¹ records the following case: A woman, aged seventy, fell, striking the palm of her right hand. She had instantly great pain and tenderness of the wrist, and complete loss of power in the hand, which became swollen; but there was no deformity nor crepitus. If, however, the hand was strongly extended, there was perceptible a yielding of the radius about an inch above the joint. She died on the fourteenth day, and the diagnosis of fracture was verified; but the periosteum on the dorsal face of the bone was untorn. The styloid process of the ulna had been wrenched off, and was adherent to the internal lateral ligament.

Besides the "silver-fork" deformity, there is in these cases an abduction of the hand, so that its radial border forms with that of the forearm an entering angle, and the ulna projects strongly on the other side of the wrist. This is due largely to the fracturing force, the hand being stopped while the weight of the body continues to drive the upper fragment downward and forward, and thus to push it into the cancellous tissue of the lower. It is easy to see that in the majority of cases the impact comes chiefly upon the radial side of the palm, in falls upon the hand, and hence that the penetration of the lower by the upper fragment would naturally be greater on that side. But this is in fact a shortening of the forearm on this margin by a change in the position and plane of the lower articulating surface of the radius, and the angle of the hand with the forearm must be correspondingly changed. The ulna does not move; it cannot, by reason of its very close articulation with the humerus above. Hence, it seems to me incorrect to speak of luxation of the ulna as an element of this lesion; it is the hand which, with the lower fragment of the radius, assumes a new position with regard to that bone. And in strictness the ulna should not be said to project, although the expression may be retained as a matter of convenience.

Perhaps I may best speak here of the views of Prof. Moore, of Rochester, who maintains that "luxation of the ulna" is the key to the pathology and treatment of the lesion in these cases. It has been already stated that there is often a twisting of the wrist along with the mere over-extension which breaks the radius, and when the change of angle between the hand and forearm, just spoken of, takes place, there must of necessity be also a change in the relations between the carpal bones and the lower end of the ulna. And by entanglement in the annular ligament or a tendon (generally, I think, that of the extensor carpi ulnaris), the correction of this latter displacement may be rendered very difficult. Admitting, however, that such a state of things exists, as claimed by Prof. Moore, in one-half of the cases, it seems to me that its absence in the other half certainly makes it secondary to the lesion which is always present. With all deference to his learning and practical ability, I am myself unable to accept his theory, to which I believe the above statement does justice; of the treatment based upon it, which has some great merits, more will be said presently.

It has been already stated that swelling takes place very rapidly after fracture in this region. When the lesion involves the articular surface, or in other words enters the joint, there is copious effusion into this cavity, and active inflammation may be set up. And in any case the sheaths of the tendons are thus distended; besides which, although at a somewhat later stage, the subcutaneous areolar tissue becomes the seat of lymphization, and sometimes, especially in feeble or aged persons, of œdematous fulness.

Simultaneous fracture of both radii near their lower extremities has been observed in many instances, the reason of its frequency being obvious.

¹ Clinique Chirurgicale, tome i. p. 164.

Nothing special need be said in regard to it, as each lesion is as independent of the other as if the limbs belonged to different bodies.

Compound fracture is very rare in this region; except in gunshot injuries, or in railroad or machinery accidents, indeed, I do not know that it is ever seen. The neighboring bones and soft parts would in such a case be likely to be also involved, and the sum of the injury would be great enough to demand amputation. In a number of instances recorded by Hamilton and others, the lower extremity of the ulna has been driven through the skin, having had the carpus torn away from it along with the distal fragment of the radius; but here the fracture is still a simple one, and the lesion just mentioned is a complication only.

Bryant¹ mentions a very curious complication, produced by a fall from a height, in a man aged thirty. "There was an impacted Colles's fracture of the right radius, and a vertical fracture of the head of the same bone into the joint." A much more common complication, especially apt to occur in cases due to direct violence, is fracture of one or more of the carpal bones, the scaphoid and semilunar being those oftenest affected.

Epiphyseal separations of the lower end of the radius have been spoken of by some authors;² but they do not present any special features as compared with ordinary fractures in this region.

When, as happens in a small proportion of the cases, the fracture is the result of a fall on the back of the hand, the distal fragment is driven forward, so that the articulating surface looks toward the palmar instead of toward the dorsal aspect of the limb. The leverage is then exerted in the direction of flexion, and not of extension, and the hand is bent forward, so that in the state of pronation it makes an angle downward with the forearm. Of this I have lately seen a striking instance, which will be further spoken of in connection with the subject of treatment.

In such cases the symptoms are very nearly the same as in those of the ordinary form of the injury before detailed; but there is a slight difference in the character of the deformity, such as will readily be understood. The lower fragment, instead of rising up on the dorsal surface, drops forward, and the "silver-fork" shape of the wrist is much less distinct.

The course of these cases is extremely variable. Unfortunately, an opportunity is not seldom presented of seeing the results of treatment so inefficient as to amount to almost nothing. Often the deformity is uncorrected, and the patient goes through life with the wrist misshapen. But as union takes place, and as the irritation in the sheaths of the tendons and in the neighboring soft parts subsides, the usefulness of the limb is restored, and the hand regains its strength, except for actions consisting in pushing, and such as require its complete flexion on the forearm.

When the force has acted on the back of the hand, it is extension that is apt to be thus interfered with, and the member acquires a claw-like appearance, aggravated in one case which has come under my notice by nerve-lesions, impairing the nutrition of the part, shrivelling the fingers, and totally abolishing strength and freedom of motion.

Under proper treatment, however, a far more favorable condition of things is brought about. Union generally takes place readily, and if the fragments have been put into proper apposition, the shape and strength of the wrist, as well as the motions of the part, are completely restored.

Between these two extremes—union with great deformity and union with perfect restoration of shape, there are of course innumerable gradations. In

¹ Manual for the Practice of Surgery, 2d Am. edition, p. 788.

² Holmes, Surgical Treatment of Children's Diseases, p. 254; R. W. Smith, op. cit., p. 165.

the majority of cases, the result obtained is a useful hand, with perhaps a degree of disfigurement not sufficient to be a serious annoyance, unless the patient be a woman in the higher walks of life. A city surgeon may almost daily see the most laborious occupations pursued by persons who have been the subjects of this fracture, as testified to by the unmistakable distortion of the affected limb—the projection of the ulna, the abduction of the hand, and the thickening of the wrist.

Anchylosis of the joint very seldom occurs; a fact which may be accounted for by the rarity of actual involvement of the articular surface. Even when there has been extreme distension of the tendinous sheaths, and the stiffening of the wrist is at first strongly marked, the parts ultimately resume their suppleness, except in the case of very old, feeble, or rheumatic subjects. Barometric pains are sometimes complained of subsequently, but not, I think, as often as after most other fractures.

The *diagnosis* of these fractures does not generally offer very much difficulty. Luxations of the wrist, with which they would be most likely to be confounded, are so rare as practically to be almost excluded from consideration. One case, observed by Lenoir, and published by Voillemier,¹ is undisputed, having been verified by dissection after the patient's death. Another, mentioned by Hamilton,² seems to me to be beyond doubt. Nearly fifty others have been recorded as such,³ but none of them can be accepted upon the evidence offered. I have had one case in which the character of the deformity, the ease of complete reduction, and the speedy resumption of the normal condition and use of the hand, convinced me that there had been a luxation of the carpus backward; and two others which I had reason to believe were of that nature, but in regard to which I feel less positive.

Admitting that luxation can occur, it is of course desirable that the distinctive features of the two lesions should be known, so far as they can be from the limited facts at command.

The pain, helplessness of the hand, and deformity, are alike in both. But on examination, instead of the rough and irregular edges of the broken bone, the fingers of the surgeon will, in the case of a dislocation, find on one side the smooth concavity of the articulating ends of the bones of the forearm, and on the other the rounded convexity formed by those of the carpus. The styloid processes, according to Hamilton, were plainly felt in his case. Preternatural mobility, apt to be present in fracture, although perhaps in but slight degree, will be wanting in dislocation, and so also will crepitus. Reduction, often very difficult in fracture, gradually effected, and attended with a grating sound, is easy, sudden, and marked by a click or snap, in luxation.

The only other lesion with which fracture could be confounded is a severe sprain, and the limits between these injuries are, as already said, very ill defined. It seems quite possible that cases are not very rare in which the bone is partially broken through, and that sometimes, when the bone is completely divided, the fragments may remain in contact, the fibrous structures being untorn. A mistake, however, would, under such circumstances, be really a matter of no moment.

The *treatment* of fracture of the lower end of the radius has been very extensively discussed, and different surgeons have held widely different views

¹ Archives Générales de Médecine, Déc. 1839; also in his Clinique Chirurgicale, p. 120. It may also be found in R. W. Smith's work before quoted.

² Practical Treatise on Fractures and Dislocations, p. 712.

³ The reader who wishes to follow up the matter can find in Malgaigne (op. cit., tome ii. p. 681 *et seq.*), and in a valuable prize essay by Dr. T. K. Cruse, published in the Transactions of the Med. Society of the State of New York for 1874, the references to these reports. I am at a loss to account for the want of correspondence between the lists given by these two authors.

as to the best means of accomplishing the indications, which in themselves are simple enough—to correct the malposition of the fragments, and to maintain them in accurate contact until union shall have occurred.

I do not know how to express strongly enough my conviction, that the great reason why deformity so often follows fractures of the radius close to the wrist, is because of failure to carry out the first of the above indications. *Reduction is not effected at all.* If this is once thoroughly accomplished, a good result can be obtained with almost any form of apparatus fitted to the case with ordinary skill and care. If it is not properly attended to, it makes no difference how elaborate may be the appliances used, the deformity will surely become permanent.

Authors have differed greatly as to the condition of such fractures with regard to reducibility. Callender said, that “in a great number of cases the impaction so fixes the fragments that they cannot be unlocked, and the deformity is permanent.” Colles, on the other hand, said: “If the surgeon lock his hand in that of the patient and make extension, even with moderate force, he restores the limb to its natural form; but the distortion of the limb instantly returns on the extension being removed.” Sir A. Cooper thought that powerful extension was required, but that the moment it was relaxed the deformity recurred. Moore holds that if the head of the ulna is disengaged from the annular ligament and tendon of the extensor carpi ulnaris, the whole difficulty is overcome. Pilcher regards the dorsal periosteum and the ligament between the cuneiform bone and the styloid process of the ulna, the former especially, as the parts at fault.

I venture to suggest that each of these practical surgeons could have cited cases in proof of his special views; and that, in fact, the conditions met with are anything but uniform. Therefore I think it vain to insist on any one method of reduction as the proper one; each case is to be studied for itself, and such manipulation adopted as seems to promise best. Failing this, some other plan may be tried.

Moore's method is a very good one: he grasps the prone hand of the patient with one hand, the forearm with the other, his thumbs being applied against the head of the ulna so as to act as a sort of double fulcrum. I have once or twice succeeded by using my knee as a fulcrum, grasping the hand and fragment with one hand, while steadying the forearm with the other. Lonsdale¹ says: “The ends of the bone may often be unlocked by suddenly supinating the arm to the utmost.”

One thing seems to me of great importance, viz., to act as much as possible directly upon the fragments themselves. Too often extension is made upon the hand alone; and although in old persons, with soft or brittle bones, such a procedure may disengage the lower fragment, yet in others, and especially if the fracturing force have been severe, and if the upper fragment have been strongly driven into the lower, it may totally fail. By such a manœuvre the soft parts may be drawn out into something approaching the normal shape, the fragments still remaining in their false relation, so that no real good is effected. Often, as Hamilton points out, the ligaments are torn. The circumduction recommended by Moore for disentangling the head of the ulna will sometimes free the lower fragment also.

Precise directions cannot, however, be given for every case. It is of the utmost consequence that the surgeon should know what is the normal form which he wishes to restore, and that he should have sufficient ingenuity and mechanical dexterity to ascertain and overcome whatever difficulty may exist in each case, as far as it is possible to do so.

¹ Op. cit., p. 146.

The fragments having been disengaged, if there have been no crushing of the cancellous substance, their apposition can be readily maintained, and it will be found that the articular face of the bone has resumed its natural position, looking slightly toward the palmar aspect of the limb. The "silver-fork" deformity will be markedly diminished, although it may be that swelling will already have taken place to such an extent as to constitute a fullness on the dorsum of the wrist. The concavity of the palmar surface of the radius will be restored, and, if the hand be placed in a natural position, neither flexed nor extended upon the forearm, the ball of the thumb will be seen to bulge strongly downward, thus apparently increasing the concavity just mentioned. At the same time the ulna will have gone back into its proper place, and the ulnar edge of the wrist and hand will make with it a slight entering angle.

It must be remembered that if there have been crushing of the substance of either fragment, or if the lower one be comminuted, this complete restoration may be impossible, and a certain amount of distortion will remain in spite of the surgeon's best directed efforts. When such is the case, the patient should be notified that he has to expect more or less deformity to be permanent.

In the rare cases in which the displacement has occurred in the opposite direction, namely, with the lower fragment bent toward the palm, the manœuvres must be modified accordingly; the details will readily suggest themselves.

I need hardly say that in cases which present any degree of difficulty, the surgeon's task will be rendered much easier by having the patient in a state of complete anæsthesia.

A very large array of splints has been devised for the treatment of fractures of the lower end of the radius. By the older surgeons, the dorsal and palmar boards were employed, with pads to push the fragments into place. Dupuytren, in the hope of correcting the projection of the ulna and the abduction of the hand, applied a curved bar along the ulnar edge of the forearm and hand; it is best known, perhaps, by its French name, as the "attelle cubitale." The same end has been sought by means of a pistol-shaped board, placed on the dorsum of the forearm and hand; some surgeons have thought that this answered a better purpose if laid along the palmar surface. By most authors this contrivance has been called "Nélaton's splint;" but it is not mentioned in that author's *Pathologie Chirurgicale*, published in 1844. Malgaigne speaks of wooden splints, "which should first cover the forearm in the ordinary way, and which at the wrist should bend sharply inward, not by their surfaces, but by their edges." These, he says, were proposed by Blandin in 1836, but had been "previously known." The fact is that the pistol-shaped splint is clearly described by Goyrand,¹ as an improved form of apparatus devised by himself.

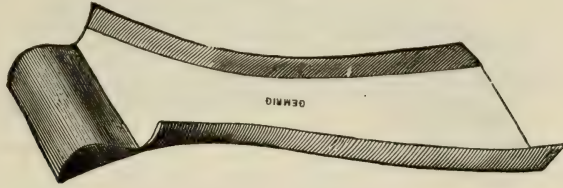
Skey thought that the hand ought to be sedulously supported; Gordon, of Belfast, believes that its weight may be made useful as an adducting force.

Bond's splint, proposed in 1852, has had a very wide popularity in America, and with some modification is a very good one. It consists of a board cut to the outline of the normal hand and forearm, and furnished with a palmar block, over which the fingers are flexed. Leather strips are generally tacked along its edges to keep the parts more secure. This splint is greatly improved by fastening along its radial margin a block of wood, so shaped as to fill up the concavity before noted as normal in this part of the limb. Without this, and especially with the palmar block as large as is usually made, Bond's splint can only keep up the deformity it is meant to correct. I

¹ Journal Hebdomadaire des Progrès des Sciences Médicales, Fév. 1836, p. 177.

make this statement from the examination of a number of cases treated by most able hands on this plan. Hays's splint, a mere temporary substitute for Bond's, is open to the same objection. Hamilton uses a splint on the same principle, but padded with horsehair, kept in place by a sack-like envelop. He employs a dorsal splint also.

Fig. 834.

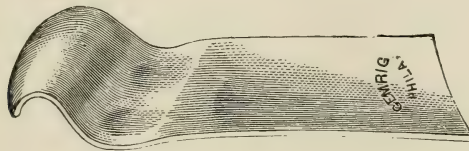


Bond's splint for fracture of the radius.

A number of years ago a splint was made by Carr, a surgeon in New Hampshire, which consisted of a slip of board to fit along the palmar surface of the forearm, narrowing at the wrist, and having nailed across it, by way of palmar block, a cylindrical bit of wood like a section of broomstick (which, I believe, the first one really was). Very good results are said to have been obtained with this, and it is certainly correct in principle. More elaborate and complicated contrivances, on the same general plan, but with adjustable blocks, have been made by others.

Coover's splint, shaped out of wood, so as to fit the palmar surface of the

Fig. 835.



Coover's splint for fracture of the radius.

forearm and hand, is sold in pairs, and of various sizes. I have repeatedly used it with great satisfaction.

Levis's splint, made of tin, answers a very good purpose; its shape and mode of use are shown in the cuts, Figs. 836 and 837. A very similar one, of what material is not stated, is described as having been exhibited by Schede, of Hamburg, at a recent congress of the German Society of Surgery.¹

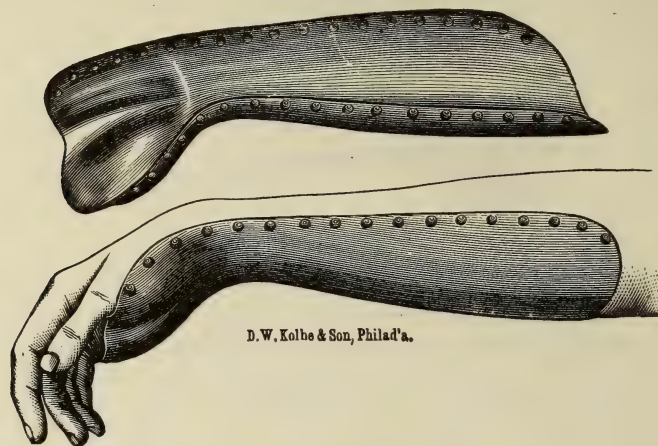
Gordon's splint deserves mention, although it is awkward in appearance; it consists of a board for the palmar surface of the forearm, with a block along its radial side, filling up the natural concavity of the part. This board extends only as far as the flexure of the wrist, the hand hanging free and tending to adduction. A shaped, dorsal splint, and straps and buckles, complete the apparatus. Both by its contriver and by others it is said to have been found efficient.

Much bolder plans, allowing more liberty to the limb, have been proposed and employed, it is said, with good results. Moore, having effected reduction in the manner before mentioned, applies a small roller firmly over the

¹ Gaz. Médicale de Paris, 19 Août, 1882.

head of the ulna, and then makes pressure over the injured part by means of a wide band of adhesive plaster. Pilcher discards the compress, and uses the plaster only. I have myself used simply what may be called a very short splint—a slip of wood shaped so as to fill up the concavity just above the

Figs. 836, 837.



D. W. Kolbe & Son, Philad'a.

Levis's splint for fractured radius.

wrist, held in place by adhesive plaster first, and then with a bandage. When reduction has been completely effected in simple cases, without comminution, either of these retentive means will suffice; but they must be applied with great accuracy, and should be carefully watched, so that additional safeguards may be resorted to, if necessary.

It should never be forgotten, in dressing these fractures particularly, that undue tightness of the bandage may lead to the most deplorable results. Reduction having been once effected, a properly fitted splint will keep the fragments in place, and permit the arm to be supported without any great constriction. All that is needed is that the roller should be put on snugly and uniformly.

My own rule is to examine the condition of the parts every second day for the first two weeks, although this may be modified if there is no derangement of the apparatus, and if at the third or fourth time the fracture is found in perfectly satisfactory condition. Under such circumstances the interval may be extended to four or five days.

Malgaigne's practice in this respect, as stated by himself, seems to me to be scarcely a safe one to follow. He says:—

“I remove the apparatus at from the eighteenth to the twenty-second day, to ascertain the condition of things, and to remedy any displacement which may have occurred; after this I do not touch it until the thirtieth day, when I leave the limb entirely at liberty. I would repeat, that by pursuing this method I have always found this fracture one of the easiest to cure, without stiffening, deformity, or the slightest impairment of the motions of the limb; excepting, of course, in those very grave cases complicated with actual luxation of the ulna.”

Schede, whose splint has already been alluded to, uses a starched bandage over one of flannel, and makes passive motion every eighth day; removing the apparatus altogether at the end of three weeks. The starched or plaster-of-Paris bandage may, I think, be used with advantage in some cases after the second or third week, especially in the case of a restless child, or when the

patient cannot be seen again for some time. Passive motion need only be made in exceptional instances, where there is a strong tendency to stiffening, such as sometimes occurs in old people, or where the violence producing the injury has been very great.

I have recently had under my care a woman who, by a fall on the back of the hand, had a fracture of the radius just above the wrist, with displacement of the lower fragment forward. Her attendant had simply applied a Levis's splint, which of course, in such a case, merely kept up the deformity. (I presume no effort to correct it had been made.) When she came to me, about two months afterward, the wrist was greatly deformed, the hand and fingers flexed, and their nutrition impaired, as shown by the wrinkled, glossy, and shrunken skin. She had constant and severe pain, and the hand was useless. By breaking up the adhesions (under ether), and prolonged treatment in the way of frictions and gentle passive motion, I succeeded in improving the condition of things, but she has not yet regained anything like free use of the hand.

Non-union must certainly be very rare in fractures of the lower portion of the radius. Muhlenberg¹ gives five cases in which this condition obtained in the "lower third" of the bone; but it is not stated that either was one of fracture close to the wrist.

When union has taken place with deformity, if too much time has not elapsed, an attempt may be made to separate the fragments by force, and to bring them into proper relation. Little² adopted such a course with success after a period of six weeks. More risk would attend a procedure of this kind, in proportion to the nearness of the fracture to the joint; and in very many cases it would be better to trust to the chance of improvement by the modeling processes of nature.

FRACTURES OF BOTH BONES OF THE FOREARM are of very frequent occurrence, in children especially. In this respect they differ markedly from the other fractures in this region, which are more commonly met with in adult life. Thus, in the tables given by Flower and Hulke,³ derived from the records of the Middlesex Hospital for sixteen years, out of a total of 2705 fractures, there were 1142 affecting the forearm, viz., the radius and ulna 191, or about 16 per cent., the ulna alone (including the olecranon) 183, or about 16 per cent., and the radius alone 768, or about 67 per cent. Of these 1142 cases, 401, or 35 per cent., were in subjects below the age of 15; and here the proportions were: for the radius and ulna 119, or over 29 per cent.; for the ulna alone (including the olecranon) 45, or over 11 per cent.; and for the radius alone 237, or over 59 per cent.

With regard to the total of fractures affecting patients under the age of fifteen years, 1154, there were for the radius and ulna over 10 per cent.; for the ulna alone nearly 4 per cent.; and for the radius alone over 20 per cent.

As compared with the grand total of 2705 fractures, the cases under the age of fifteen were: in the radius and ulna over 4 per cent.; in the ulna alone 1 per cent.; and in the radius alone nearly 9 per cent.

Agnew's general table⁴ includes 8667 cases of fracture treated at the Pennsylvania Hospital in forty-four years; of these, 1802, or nearly 21 per cent., concerned the bones of the forearm, and were distributed as follows: In the radius and ulna 599, or over 33 per cent.; in the ulna alone 218, or something over 12 per cent.; and in the radius alone 985, or over 54 per cent. The reader will note a discrepancy of result between these figures and those pre-

¹ Agnew, *op. cit.*, vol. i. p. 768.

² Holmes's *System of Surgery*, 3d ed., vol. i. p. 946.

³ Medical Record, March 4, 1882.

⁴ *Op. cit.*, vol. i. p. 824.

viously quoted, which is sufficient to attract attention, but which it is not easy to explain. Agnew's tables are not so arranged with regard to the ages of the patients as to enable a comparison to be made in this respect.

Among the 316 cases of fracture before quoted from the records of the Children's Hospital, in Philadelphia, 105, or a little over 33 per cent., affected the bones of the forearm. Of this number, 36, or over 34 per cent., affected both the radius and ulna; 15, or over 14 per cent., the ulna alone (including the olecranon); and 54, or over 51 per cent., the radius alone.

As to the influence of sex, Malgaigne says that "they are equal in number from two to fifteen years; from fifteen to twenty, there are eighteen males to one female; from twenty to forty-five, the number of men is just double that of the women; after forty-five, the women regain their equality, and even exceed it, being twenty-two to nineteen."

It is in this region, as stated in the early part of this article, that bending or incomplete fracture has been chiefly observed.

The *causes* of fractures of both bones of the forearm are most frequently indirect, such as falls on the hand. The mechanism is not always clear; that is, it does not appear why a fall of this kind should sometimes give rise to fracture of the radius alone, close to the wrist, while in other cases both bones give way in their shafts. Probably it is sometimes due to a difference in the mode of impact, and sometimes to the elasticity and toughness of the radius, and the thickness of the periosteum, which prevents yielding, except at the thinner and less protected position of the shaft, the ulna breaking an instant afterward for want of support.

Direct violence may affect this part of the skeleton in various ways: machinery accidents, falls against resisting objects, crushing forces, as by the passage of a wheel, the kick of a horse, blows, etc. Muscular action, in a case recorded by Malgaigne, and in two other instances,¹ has been known to cause fracture of the forearm.

Occasionally there is double fracture, each bone giving way at two points; and comminution is not seldom met with. Either of these conditions is apt to occur in cases due to direct violence, especially in machinery accidents, as when the arm is drawn around a revolving shaft.

Sometimes the two bones are broken at the same level, but they may give way at different points, and then the fracture of the radius is apt to take place higher up—nearer to the elbow—than the fracture of the ulna. This fact may be accounted for partly by the comparative slenderness of the radius above, and of the ulna below; partly, perhaps, by the muscular attachments of the former bone.

Hamilton mentions one case seen by him, in which "the radius was broken three-quarters of an inch above the lower end, and the ulna about one inch below the coronoid process." This is certainly very rare, and it is to be regretted that no details are given either as to the causation or the ultimate result of the injury. Fractures situated so far apart might almost be considered as wholly separate lesions.

Upon the occurrence of fracture of both bones of the forearm, however caused, more or less displacement of the fragments commonly ensues. Very often the fracturing force has much to do with this, but muscular action can scarcely fail to influence it. The resulting condition may be very simple, but it may be very complex. Sometimes the bones retain their parallelism, but are bent backward, forward, or to either side. Sometimes the two upper fragments are pressed together, and the two lower ones separated, or *vice versa*. Again, either by the fracturing force or by subsequent changes of position of

¹ Gurlt, op. cit., Bd. i. S. 244.

the hand, a twisting may take place which brings the four fragments into most complicated abnormal relations to one another. Occasionally the interosseous ligament is torn at the time of the accident, or it may be penetrated by one of the fragments, and in either case a most puzzling and intractable entanglement may ensue.

Fortunately, such embarrassing conditions are infrequent; in the great majority of cases the forearm is simply bent at an angle, the two bones remaining parallel. Most commonly the angle thus formed is salient on the dorsal surface.

It will very readily be seen, however, that even a slight bending of the bones will do away altogether with the freedom of rotation of the radius upon which the use of the hand so largely depends; and this, whether one bone or both be involved. And if, in addition to the formation of an angle, there is rotation of either of the three fragments which can be so affected (for the upper portion of the ulna is fixed by its connection with the humerus), the limitation of movement may by this fact be made materially greater. Such rotation is most likely to take place in the upper fragment of the radius, acted upon by the biceps and supinator brevis; but it is not impossible that by pronation of the hand, aided by the pronator muscles, the lower fragment of this bone may be turned in the opposite direction. The position of the lower portion of the ulna may be slightly affected by the upper fibres of the pronator quadratus, drawing it toward the radius, but it is more likely to be influenced by the position of the hand.

Whatever abnormalities of relation may be assumed by the fragments, and by means of whatever agencies, the action of the muscles passing down along the forearm can scarcely be ignored among the causes promoting displacement. These muscles, left to themselves, tend to shorten the forearm, and when the continuity of the bones is lost at any point, they must draw the fragments past one another, and in this way aggravate their distortion.

The evils to be apprehended from the changed position of the fragments are not limited altogether to angulation of the bones. Non-union may follow, and so far from the motions of the hand being hampered, the bones may be so loose as to be unavailable for any ordinary purpose. Or the wrong fragments may become attached one to another; or a mass of callus may be thrown out and fuse all the broken ends into a rigid and useless block. Rare as these unfortunate occurrences are, they have been met with, and illustrations of them are to be found in most pathological collections.

The *symptoms* of the fractures in question are not often obscure; deformity is sometimes present in so marked a degree as to reveal at once the nature of the lesion; pain, loss of power in the hand, abnormal mobility, and crepitus, are seldom absent. Hence, the *diagnosis* need not be discussed.

From what has now been said, it will be perceived that the consequences of these injuries may be very disastrous, if, as in cases occurring at sea, no treatment can be had for some time; or if the surgeon be careless or unskilful, or the patient unruly. And although under favorable circumstances good results can generally be obtained, the chance of some degree of impairment of motion should always be borne in mind, and should qualify the *prognosis* given to the patient or his friends.

The *treatment* must be based on general principles, but must be carefully adapted to the features of each case. It consists in the reduction of the fragments to their proper relation, and in maintaining them thus until they have become united.

When the deformity consists in a simple bending of the forearm in either direction, it may often be corrected by the mere application of the surgeon's hands; but sometimes it is necessary to make extension also. During any

manceuvre of this kind, the elbow should be flexed to a right angle, and the hand placed semiprone. It is much better to have the extension and counter-extension made by an assistant, leaving both hands of the surgeon free to manipulate the injured part. Along with the extension, some rotary movements may be needful in order to the disengagement of the fragments from one another, or from the interosseous ligament. All this must be done with the utmost gentleness, the amount of force used being determined by the resistance met with; each movement should be made with a definite purpose, and its effect carefully noted, lest the existing displacement be only increased, and further damage done to the soft parts.

Some idea may be formed beforehand of the objects to be aimed at in this procedure, by a careful study of the seat of fracture, and of the condition of the parts—the degree and direction of obliquity of each fracture, the relation of the fragments to one another, the point at which each bone, but especially the radius, has given way, and the amount of entanglement of the soft parts. But in cases presenting much complexity, there may be much that must be left to be ascertained during the manipulation.

Having brought the fragments into proper apposition, the next point is to keep them so. As to the best mode of doing this, authors are not entirely in accord; some advising supination of the forearm, others semi-pronation. I think that the rule here should be the same as that given for fractures of the radius alone, viz., that when this bone is broken above the insertion of the pronator teres, supination is best, because it allows the lower fragment to follow the upper; whereas in fractures below this point the upper fragment is not so liable to be supinated. I do not think that this latter fact is due as much to the action of the pronator teres muscle, as to the greater length of the fragment and the more superficial position of its lower end, making it more controllable. Ramonet¹ thinks that the forearm should be kept in semi-pronation for two weeks, as the most comfortable position; and that passive motion should then be carefully and skilfully made. Either in supination or in semi-pronation there is no difficulty in maintaining the interosseous space, if the fragments are once properly placed.

The practice of applying an “immediate” roller to the limb is more objectionable here than in any other region of the body, for the obvious reason that its tendency is to press the fragments together, and thus to destroy the interosseous space, and to permanently impair the rotation of the hand.

When the supine position is to be maintained, the best splint for the purpose is the ordinary, anterior, right-angled one, with a small, narrow, firm pad laid along the middle of the forearm part. This pad should reach from about an inch below the elbow to about the same distance above the wrist. It is not intended to be forced in between the bones, but merely to compress the muscles and push them gently into the interosseous space. In some arms a corresponding splint may be employed on the under or dorsal side; but it must be very carefully applied, and should not extend upward far enough for the prominent ridge formed by the ulna to interfere with its usefulness.

Extension may be made, if necessary, from the end of the upper splint, either by means of a glove with the fingers cut off, or by strips of adhesive plaster. The splint should, therefore, extend two or three inches beyond the ends of the fingers.

Another very good splint in principle, but I should suppose rather more difficult of effective application, is that of Dr. X. C. Scott, already mentioned in connection with the treatment of fractures affecting the radius only.

¹ On the influence of retraction of the interosseous membrane on the loss of supination in fractures of the forearm; *Archives Générales*, Août, 1881.

In cases suitable for semi-pronation, the best splint is an "internal angular" one, extending from about the middle of the arm to the ends of the fingers, or further, if extension needs to be made. A dorsal splint, padded somewhat more thickly along the middle than at the edges, and extending from opposite the bend of the elbow to a point just above the wrist, should also be employed. These splints should be just the width of the arm at each point; if they are wider, the forearm may be bent toward the radial or ulnar side, and if narrower, the pressure of the bandage may drive the fragments toward one another. Hence my own practice is to shape the splints beforehand by taking an outline from the sound limb, and cutting away the parts outside of this outline.

When binders' board is used as the material for the splints, the ulnar edge of the forearm-part may be slightly turned up, so as to afford support to this portion of the limb.

By most surgeons, anterior and posterior splints are applied to the forearm only, and by many the pads for preserving the interosseous space are thought to be "if useful, intolerable; if tolerable, useless."¹ I can only say that, in my opinion, one cause of disturbance of the fragments, in these cases, is the constant, slight, irregular, but unopposed pulling of the muscles, due to continual slight movements of the elbow; hence I would put the forearm at absolute rest by confining the elbow also. Another disturbing cause is the rotation of the forearm, which is effectually prevented, and the thumb kept upward, by simply adding the arm-part to the palmar splint. As to the pads, the mistake generally made is to have them too large in every way, and thus to get pressure where it is not wanted. I think that they should be exactly adapted in size to the space between the bones in each case, and, above all, that they should not be too long.

I attach much importance, not only to keeping the upper fragments at rest by confining the elbow, but to doing the same for the lower fragments by giving due support to the hand, which should be placed at the proper or natural angle with the forearm, slightly adducted. The hand should never be allowed to hang down, as this would tilt up the lower fragments of both bones, and cause an angle salient toward the radial edge of the forearm. The sling should be wide, and should give the forearm perfect support; but if the previous dressing have been properly done in the manner above described, there can be no risk of bending, even if only a narrow sling be used.

After the first dressing, there may be no occasion to disturb the apparatus for several days, if it continue firm, causing no pain, and if the circulation be shown by the state of the fingers to be properly carried on. The splints should then be removed for the purpose of thorough examination, and immediately reapplied. After this the dressings should be renewed about once in forty-eight hours, and at the end of three weeks very gentle passive motion may be attempted, the surgeon taking hold of the forearm above and below the seat of fracture, and rotating the two parts in exact accord. The fracture remaining firm, at the end of the fourth week the fingers may be left free, and two or three days afterwards the part of the splint corresponding to the hand may be removed, as well as the arm-part. After this the dressing may be left on until it becomes loose, and then, on its removal, it will probably be safe to leave it off entirely.

In children union takes place more quickly; I recently attended a little girl, three years old, whose forearm, broken at about the middle, was quite firm on the fourteenth day.

These fractures afford a striking illustration of the fact, noted in the early

part of this article, that the absence of pain or discomfort in a broken limb does not give assurance that it has been properly and efficiently dressed. Not a few cases have been observed in which the fragments have been twisted into utterly abnormal relations, while yet the patient has been wholly unconscious of anything being wrong.

The great risk of gangrene in this part, from too tight bandaging, has already been referred to, and ought always to be borne in mind when the dressings are applied. Sometimes it is questionable whether an accident of this kind is not due to the contact of the fragments with the vessels, which by thorough reduction would have been obviated.

Dr. Hamilton, in his report¹ before quoted, mentions three cases of young children, in which no dressings whatever were employed, yet in which the results obtained were perfect.

He refers to another instance;² in which a boy of ten years, after a fracture near the lower end of the forearm, had so great a deformity that refracture was seriously thought of by his attendant; gradually, however, the limb became straight, and eighteen years afterward there was no trace whatever of the injury.

Non-union has occurred many times in fractures affecting both bones of the forearm, and for obvious reasons is a cause of more complete disability here than in some other regions. Moreover, the chance of affording relief by prosthetic apparatus is less; so that operative interference is very apt to be called for. References to published cases of this kind may be found in the first part of this article.³

Refracture sometimes occurs in the forearm, and may affect either one or both of the bones previously broken. When only one suffers, the other, of course, acts as a splint; when both are broken, the case demands the same care and attention as in the first instance, but union is apt to take place more rapidly.

Compound fractures of both bones of the forearm are very often met with in hospital practice, as the result of railroad and machinery accidents. They vary widely in their extent and gravity, and in the complications which they present. No directions can be given for the management of these injuries when amputation is not called for, other than the general laws elsewhere laid down. Often the real treatment of the fracture can only begin at a comparatively late stage of the case, and with very little hope of saving a shapely and useful limb. Yet it sometimes happens that nature, aided by care, attention, and skill, accomplishes unexpectedly good results; and as even a maimed limb is apt to be better than an artificial substitute, the surgeon's trouble and the patient's endurance will be well expended in its preservation.

FRACTURES OF THE HAND.

FRACTURES OF THE CARPAL BONES.—These have been observed almost exclusively in connection with fractures of the lower part of the radius, and as the result of direct violence. Malgaigne mentions two cases seen by Cloquet, and one by Jarjavay; but he does not say expressly that there was no other lesion present. The scaphoid and semilunar would seem to be the bones almost always involved, as might naturally be expected from their close connection with the radius. I can only say, theoretically, that if by direct

¹ Trans. of Am. Med. Association, 1856, pp. 198 and 199.

² Case 28; op. cit., p. 201.

³ Page 63. See also cases recorded by Dukes (Lancet, Dec. 7, 1878) and by Gant (Ibid., May 8, 1880).

violence fracture of these bones alone should occur, inflammation of the neighboring joints would be very apt to follow. The injury would scarcely present any distinctive features, and would be amenable only to the same treatment as a severe contusion of the part. Unless caries or necrosis should ensue, or the inflammation extend to the synovial membrane between the rows of carpal bones, no permanent disability would be likely to result.

FRACTURES OF THE METACARPAL BONES.—These are not very unfrequent in men of the laboring class. They are sometimes met with in machinery accidents, and then are almost always compound. Indirect violence, either from falls on the hand, or from striking a blow, is a common cause of the simple fractures. I have seen one case, in a powerful sailor, in which necrosis had ensued upon a fracture of the fourth metacarpal bone, sustained by striking another man on the jaw. Malgaigne quotes from Velpeau an instance in which “a water-carrier had his fore and middle fingers pulled upon by a carter with such force as to break the third metacarpal bone.” He also quotes from Dupuytren a case in which fracture was due to forcible bending backward of the bone: “Two men were trying which could pull back the other’s wrist; their fingers were interlocked, the heads of the metacarpal bones directly opposed to each other, and the phalanges bent back and pressing firmly against the dorsum of the hand; the stronger of the two broke his adversary’s third metacarpal bone.” Usually only one bone is broken, and the experience of surgeons seems to have been strangely different as to the one most likely to suffer. According to some, it is that of the index finger; according to others, the fourth or fifth. Agnew says that he has never seen fracture of the first named, nor have I; but Hamilton records a number of cases observed by himself.

I have said that these injuries were apt to affect men of the laboring class, but Agnew¹ says that he had one case in a child of three years, and another in a man of eighty-five. Hamilton mentions one in a boy of eight, and another in a young lady of eighteen. Children, from the smallness of the bones, the slight leverage therefore afforded, and their customary protection from the violence apt to cause such fractures, are, in great measure, exempt from them; and the same may be said of women.

The seat of fracture, in cases due to direct force, may be at any point; in such as are produced by indirect violence, the bone is most apt to yield a little below its mid-point, so that the distal fragment is slightly the shorter. The line of fracture is oblique, the proximal fragment being bevelled at the expense of its palmar face.

The *symptoms* are pain and deformity, the distal fragment and head of the bone sinking, so that the knuckle seems to be as it were effaced; there is a dorsal projection at the seat of fracture; abnormal mobility may be very distinct, but is sometimes only slight; crepitation may be felt, but obscurely, from the small size of the bone. The proximal fragment is comparatively fixed, and in the examination the distal fragment must be grasped between the surgeon’s thumb and finger, applied on the dorsal and palmar surface of the head of the bone; or it may be moved by means of the finger.

As to the *diagnosis*, although Sir A. Cooper² says that the appearance is that of dislocation, I have never seen a case in which a mistake could be made between the two lesions. If there is no prominence at the seat of fracture, there will always be tenderness there, and perhaps a sense of yielding under firm pressure. Cases may, however, occur in which the fracture is situated very near the head of the bone, and especially if swelling comes on

¹ Op. cit., vol. i. p. 918.

² Op. cit., p. 506.

rapidly, when the diagnosis is a matter of more difficulty. Such an instance has been placed on record by Townsend.¹ Occurring, as they do for the most part, among people of the rougher class, these fractures are apt to be less carefully looked after than those of greater apparent importance; and hence persistent deformity is often seen, and non-union is occasionally met with. Serious interference with the function of the hand is very rare. Hamilton, however, saw a case in which, the metacarpal bone of the index finger having been broken in striking a blow, suppuration followed, and four months after the injury "there existed complete ankylosis at the wrist-joint, and partial ankylosis in the fingers. The hand was deflected forcibly to the radial side. At the point of fracture the fragments were salient backward and quite prominent, but firmly united." It would seem that here there had been thecal abscess, involving the joints secondarily; but such lesions often occur quite independently of any fracture.

The *treatment* consists in restoring the shape of the bone, by filling up the cavity of the palm with some firm body, such as a ball or a mass of tow, and confining it in place by means of a roller or adhesive plaster. Agnew advises a splint, to extend along the palmar surface from the elbow to the ends of the fingers, with a wad of tow in the palm. I think that the ordinary Bond's splint, with the block cut away into an oval shape, would answer as well. Malgaigne, in one case, found two small transverse splints, well padded, effectual.

Non-union would in most cases be productive of so little real inconvenience, that it would not be justifiable to resort to any operative procedure to remedy it. Possibly, if the metacarpal bone of the index finger were the one concerned, some of the less severe measures might be adopted; but it would be very unfortunate if the result should be thecal abscess, and a great aggravation of the disability.

FRACTURES OF THE PHALANGES are not very uncommon; the bones of the thumb are more rarely broken than those of the fingers. Of the latter, I think the index and middle fingers are most liable to fracture, but the others are by no means exempt; the experience of different surgeons varies in this respect. The distal phalanges would seem to be less apt to suffer than the proximal, and the intermediate ones less than either. These injuries have been met with at all ages, and in both sexes, although men are much more exposed than women to the direct violence which is their usual cause. They are very apt to occur to machinists, masons, etc., and are not unfrequent in baseball players. One case of fracture of the proximal extremity of the index-finger by muscular action, has been recorded by Bellamy.² The patient, a man aged fifty-five, made a miss in striking a back-handed blow. It must be obvious that force sufficient to break one of these bones would be very likely to comminute it, and to inflict serious damage upon the soft parts also; hence these fractures are very often compound.

I once saw a separation of the palmar margin of the articular face of the first phalanx of the index finger, in a young lady, caused by a blow against the sharp edge of a bedstead; the fragment was plainly to be felt. No serious inflammation followed, and union took place favorably. Most of these injuries are much more grave. A year or two since I was called into the street late at night to see a gentleman who, in going home, had slipped upon the icy pavement, and catching at a spiked railing, had impaled his middle-finger upon one of the points, splitting the first phalanx from end to

¹ Philadelphia Medical Times, Oct. 16, 1871.

² British Med. Journal, March 28, 1874.

end. I had to cut through the soft parts of the side of the finger to liberate the hand. Amputation was unavoidable, and was performed the next day, with an excellent ultimate result.

The *symptoms* need hardly be detailed, as they are those of fractures generally, and from the small amount of covering of the bones are readily to be made out. On account of the strength of the flexors, the deformity is apt to be an angle, salient at the back of the finger; but this rule is not uniform, as the fracturing force may drive both fragments toward the palmar surface. Occasionally these fractures are complicated with dislocation, but this, except in the thumb, is in general reducible without great difficulty. Union almost always takes place without hindrance; but I have reported¹ the case of a child three years old, who had two years previously sustained a fracture of the first phalanx of the thumb, with the subsequent formation of a false joint, and on whom an operation was performed with success.

Necrosis of the fragments sometimes occurs, especially in compound and comminuted fractures; and in these cases more or less thecal inflammation is very apt to ensue, and may travel up and even beyond the wrist. Under the most favorable circumstances some degree of stiffening and deformity is often permanent, although it may not interfere with the usefulness of the finger. Stoker² showed to the Pathological Society of Dublin the skeleton of an index-finger, illustrating union of a fracture of the second phalanx. The first phalanx was entire and healthy; the articulation between the first and the second had disappeared, and there was firm osseous union between these bones. Strong ligamentous union existed between the second and third phalanges. Occasionally patients find fingers which are thus stiffened so much in the way that they are anxious for their removal; but in general they learn in time to disregard their presence. A far greater annoyance is sometimes caused by the twisting of a broken finger, so that it either crosses another, or constantly rubs against it in the movements of the hand.

As to the *treatment* of these cases, a good deal of ingenuity has been expended upon the devising of splints of various kinds. I believe that the best plan is to employ a piece of sheet zinc of suitable size, bent up so as to fit the palmar surface of the finger; this being very carefully padded and applied, may be secured by means of the best procurable adhesive plaster, or by a bandage imbued with a solution of silicate of potassium. If sheet zinc cannot be had, small strips of wood may be employed, carefully padded, and placed one on the dorsal and one on the palmar surface of the finger. As a temporary expedient this would answer perfectly. When no other means of solidifying the bandage can be had, flour and white of egg may be employed. The finger should be slightly flexed, but at the joints only. Passive motion may be carefully and gently made at the end of ten days or two weeks.

In cases of *compound fracture* the question of amputation comes up, and must be settled on general principles. Excisions are not available here, and if any portion of bone must be lost, it is better to remove the finger. I have several times seen very unsatisfactory results follow the less decided course.

FRACTURES OF THE LOWER EXTREMITY.

These injuries differ from those of the upper extremity in some important respects. As a general rule, they involve the necessity of confinement, often keeping the patient in bed. The greater size of the bones renders the repair a more tedious process, and entails some additional dangers, as for example,

¹ Am. Journal of the Med. Sciences, July, 1875.

² British Med. Journal, Dec. 31, 1881.

those of fat embolism and of pyæmia. Extension is demanded in a larger proportion of cases, and by more powerful means. All the apparatus used must be on a larger scale. Arrangements must be made for the evacuation of the bowels and bladder, without disturbance of the broken bones. Often the risk of bedsores has to be guarded against.

Yet the same general principles are to be observed—the same methods of study, the same rules as to diagnosis, and the same care for the avoidance of deformity.

FRACTURES OF THE FEMUR.

The femur, the largest bone in the body, and the most complicated in shape, is among those most frequently broken. The proportion varies in the experience of different observers, and even in the same hospital at different periods. Gurlt cites tables¹ from which I derive the following statements:—

Middeldorpf, among 325 fractures treated in the Allerheiligen Hospital, at Breslau, from 1849 to 1853, found 25, or something over 7 per cent. of the femur.

Lonsdale, at the Middlesex Hospital, in London, between 1831 and 1837, found among 1901 fractures 181, or over 9 per cent.

Gurlt, in the Hospitals and Surgical Polyclinic in Berlin, from 1851 to 1856, found 510, or less than 12 per cent. out of 4310.

Blasius, in the Surgical Clinic and Polyclinic at Halle, between 1831 and 1856, found 97, or over 12 per cent. out of 778.

Malgaigne, from the statistics of the Hôtel-Dieu from 1806 to 1808, and from 1830 to 1837, embracing 2328 fractures, found that those of the femur were 308, or over 13 per cent.

Lente, studying the records of the New York Hospital between 1839 and 1851, found that out of 1722 fractures there were 280 affecting the femur, or over 15 per cent.

Matiejowsky gives from the Allgemeiner Krankenhaus, at Prague, from 1843 to 1855, 1086 fractures, of which those of the femur were 199, or over 18 per cent.

Thus it appears that, from these seven sources, are derived results varying between 7 per cent. and 18 per cent.; a fact probably to be accounted for partly by the circumstances of the populations from which the patients were respectively drawn, and partly by the fact that, in some institutions, the general statistics are swelled by the inclusion of walking cases, while in others these are referred to dispensaries, etc.

From the statistics of the Pennsylvania Hospital for eighty-seven years, from 1751 to 1838, Wallace gives, out of 1810 fractures, 291, or about 16 per cent. of the femur; while Norris, for the period of twelve years, from 1838 to 1849 inclusive, found among 1441, 195, or over 13 per cent. of the femur. This difference, although not very marked, is not easy to explain. On the other hand, it is readily seen why, out of the 316 cases of fracture before quoted from seven years' records of the Children's Hospital, in Philadelphia, only 14, about 4½ per cent. affected the femur; for by reason of the unwillingness of parents to send their children to public institutions, a large proportion of these cases are treated at their homes.

This statement is singularly at variance with that of Holmes,² that "fractures of the shaft of the femur are among the commonest of all fractures in childhood;" and Gurlt's table,³ of 1383 fractures, arranged according to age, shows, among 330 below the age of fifteen years, 60, or a little over 18 per cent., in the femur.

¹ Op. cit., S. 6.

³ Op. cit., S. 11.

² Surgical Treatment of Children's Diseases, p. 258.

The records of the Pennsylvania Hospital¹ show, out of 248 cases of fracture of the femur in which the age is noted, 80, or 32 per cent., under twenty years of age; 47, or nearly 19 per cent., between twenty and forty years of age; 71, or over 28 per cent., between forty and sixty; and beyond sixty, 50, or 20 per cent.

The influence of sex on the frequency of occurrence of fractures of the femur is strongly marked, but not equally so with regard to all portions of the bone. During childhood and youth, when the neck of the bone is almost exempt, the number of cases in males is very much greater than that in females. Afterwards, the ratio of the two sexes becomes more nearly equal; but in old age, when the neck is the part of the bone most frequently broken, the proportion of women is in excess.

The analogy which exists between the anatomical form of the femur and that of the humerus obtains also in regard to their fractures. Thus, we have in the femur, fractures of the neck, of the trochanters, of the shaft just below the trochanters, of the shaft in other parts of its length, and of the condyles. But it will be noted that while the upper portion of the humerus, as stated in a previous part of this article, is less frequently broken than the lower, the converse is true of the femur; and the anatomy of the neck of the femur is more complex than that of the condyles, while in the humerus the upper extremity of the bone is much the simpler. The epiphyses of the humerus are far more frequently separated by violence than those of the femur. In fact, according to Holmes,² separations of the upper epiphysis of the femur are "unknown, except, perhaps, in the foetus;" this statement is too sweeping, but the lower is much oftener detached, as will hereafter appear.

A correct knowledge of the external anatomy and internal structure of each portion of the femur is essential to the understanding of its fractures. The general mechanical principles concerned have already been laid down.³

FRACTURES OF THE UPPER PART OF THE FEMUR are such as involve the neck of the bone, or the trochanters, or both. On examining a normal femur, it is seen that the neck, projecting upward from the oblique inter-trochanteric line, is set at an angle more or less obtuse with the shaft. In front, the surfaces of the two portions are nearly continuous, whereas posteriorly the line is a very marked ridge, and defines a deep hollow between it and the head. Hence, the greater trochanter projects backward, and the general shape of the neck of the bone is slightly convex in front, deeply concave behind.

The angle at which the neck is set on to the shaft, is found, on comparison of femora from different subjects, to vary considerably. Ward says that it is on an average about 125°. Whether it changes in the same skeleton from youth to old age, has never been determined, although it has been so supposed by almost all writers on anatomy and surgery. Sir Astley Cooper⁴ gives a very clear description of degenerative changes seen by him in old bones, and in the excellent illustrations accompanying his text, there may be perceived an arrangement of the cancellous structure, which, as I shall presently try to show, has much to do with the clinical features of all fractures in this region. But although these changes may undoubtedly occur, and are more frequent in old age, they are, I think, only parts of a degeneration which, in some individuals only, affects the entire skeleton. In many old bones no such change is to be noted; the neck is at a very obtuse angle with the shaft, and its structure, like that of the bony system at large, resembles that of most

¹ Surgery in the Pennsylvania Hospital, p. 280.

² Surgical Treatment of Children's Diseases, p. 258.

³ See pp. 13 *et seq.*

⁴ Op. cit., pp. 134 *et seq.*

bones at earlier periods of life. On the other hand, as shown by Gulliver,¹ such changes may occasionally occur as the result of injury in young persons and adults.

Another point to be noted, which also varies in different individuals, is the constriction of the neck close to the head. Sometimes very marked, this constriction is in some bones scarcely present at all. When it exists, it must obviously influence the probability of fracture taking place at this point, especially if the nutrition of the skeleton becomes impaired by age or any other cause.

The relation of the head of the bone to its neck also varies. Sometimes the neck extends more upward at the lower surface, so as to give the outline of its junction with the head, as seen either from before or from behind, an S-shape, and so as to lessen the relative length of the upper surface of the neck.

Variations exist also in the actual length of the neck. It is in general proportionate to that of the shaft, but not always so; as, for instance, in dwarfs, or short persons, it is longer, and in very tall persons shorter, than it would be according to such a rule.

The antero-posterior is usually less than the transverse diameter of the cervix.

A careful examination of vertical sections in the length of the head and neck of the femur shows, as pointed out by Ward, Wyman, and others, that a number of the lamellæ, beginning at the upper end of the inner wall of the shaft of the bone, close to the lesser trochanter, diverge upward to the concavity of the thin layer of compact substance covering the head, so as to receive the weight of the body upon their extremities. Another series of columns may be seen running outward from the same point, and meeting other columns running up inward from the outer wall of the shaft; these two sets of columns forming a series of groined arches culminating at the upper wall of the neck of the bone, a little to the inner side of the greater trochanter. By this arrangement, the shifting of the weight toward the outer or upper portion of the head is provided for, the pressure coming in greater degree on the outer wall of the shaft, the inner, however, receiving its share through the inner columns of the arches. The remainder of the lamellæ run in various directions, not capriciously nor at random, but so as to afford in the aggregate a very strong support to the solid but thin wall of the bone.

The capsular ligament, properly so called, extends from the edge of the cotyloid ligament to the base of the neck of the bone; that is, to the root of each trochanter, and to the ridges which connect them before and behind. When laid open, this is found to be lined by the synovial membrane, which is reflected from it to the neck of the bone, the line of reflection not corresponding, however, with that of the attachment of the capsule. A portion of the cervix is, therefore, surrounded only by fibrous tissue, the outer layer of which belongs to the capsular ligament, while the deeper is the periosteum, the two being inseparable by dissection.

I think that generally the distance between the reflection of the synovial membrane and the inter-trochanteric lines is about half an inch; one or two pockets, however, existing, where the joint cavity is somewhat prolonged outward. One of these pockets is usually just within the gemelli muscles in the digital fossa, behind the greater trochanter. Differences exist between different individuals in regard to the precise relative extent of the synovial membrane and the neck of the bone.

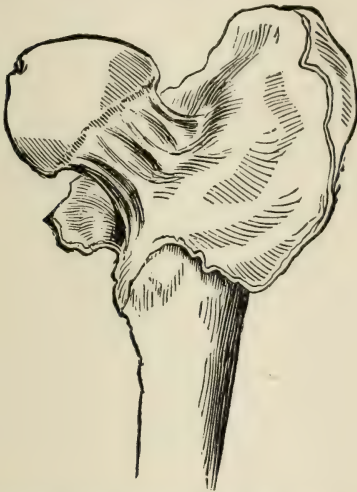
An arrangement of the immediate investment of the neck of the femur (called by Amesbury "the close coverings") which seems to have escaped the

¹ Edinburgh Med. and Surg. Journal, July and October, 1836.

notice of writers on anatomy, is, I think, of importance. Under this portion of the synovial membrane are often to be noticed, raising it into longitudinal folds, several strong ligamentous bands.¹ (Fig. 838.) Once, in a fresh subject, a vessel of some size was seen by me running along one of these folds. Another subject, a woman, had in each hip-joint three such folds, directed obliquely (spirally) from left to right in that of the left side, and from right to left in that of the right; these were in addition to the longitudinal bands above described.

When these folds exist, they must obviously exert an influence in diminishing the chance of fracture of the cervix, and in the event of such fracture,

Fig. 838.



Ligamentous bands beneath synovial capsule of hip-joint. (After Amesbury.)

Fig. 839.



Diagram showing lines of fracture in upper part of femur.

such of them as are unbroken must tend to prevent displacement. Possibly, vessels borne by them may be of importance in the nutrition of the pelvic fragment.

The principal lines of fracture in the upper part of the femur are shown in the diagram. (Fig. 839.) The neck may be broken across just below the head; or the fracture may begin below, just at or near the lesser trochanter, and run up obliquely across the neck, with more or less serration; or the greater trochanter may be broken off. In not a few instances the latter lesion has been produced by the wedge-like action of the pelvic fragment, the main breakage being of the preceding form; and sometimes the lesser trochanter also has been detached. Of course, in such a case, the fracture would be properly called a comminuted one.

In the many and voluminous discussions bestowed upon this subject of fractures of the neck of the thigh-bone, it seems to me that certain facts, anatomical, mechanical, and pathological, have been too much disregarded. The anatomical facts have been set forth above, and the others will presently be mentioned.

Authors have been generally agreed in dividing these fractures into intracapsular, extracapsular, and mixed. Under the first head are those which separate

¹ Called by Weitbrecht "Retinaeula." They are spoken of by Harrison, in the *Dublin Dissector*, and by Todd, in the *Cyclopædia of Anatomy and Physiology*, Art. Hip-Joint.

the neck in a direction almost or quite transverse; under the second, those which involve the portion of bone close to the lesser trochanter; and under the third, those which begin near the trochanter and run upward across the neck of the bone to a point close to the margin of the head. But unless the description above given of the extent and attachments of the capsular ligament is incorrect, all these fractures are within the capsule. A more correct phraseology would be "intra-articular" for those which concern the part of the bone beneath the synovial membrane of the hip-joint, and "extra-articular" for those which are wholly outside of it. Of the latter class, I think, very few examples can be found, the great majority of cases being those in which the fracture affects the bone partly beneath the synovial membrane and partly beyond its limits. Bigelow says: "In lecturing upon this subject, I have been in the habit of dividing the injuries of the neck of the femur into the impacted fracture of the base of the neck and the unimpacted fracture of the rest of the neck, without regard to the capsule—a practical classification, embracing a majority of cases, and to which the other lesions may be regarded as exceptional."

Viewed mechanically, the femur is a bent lever, arranged for the purpose of receiving the weight of the body, and of being moved so as to transfer it from place to place. Any force brought to bear upon the femur so as to tend to diminish the angle between the neck and the shaft, in other words, any force driving the head downward or the shaft upward, the opposite end being prevented from yielding, may cause a fracture beginning at the lesser trochanter, and tearing away the mass of lamellæ described as radiating upward from that point toward the head. This will only happen if the force is excessive, or if it bears upon the bony texture out of the proper line of transmission of the weight of the body. A blow upon the greater trochanter may do it, or a blow either in front or behind the base of the neck of the bone; in either case the central point of the neck, as it might perhaps be called—the apex of the pyramid of columns—is the starting-point of the rending of the bone. This idea can readily be understood by any one who will carefully examine a vertical section of the upper portion of a well-developed femur. Moreover, such a section will show also how the greater trochanter may be split off.

Out of a very large number of specimens of fracture of the neck of the femur which I have examined, every one which belonged to the "extracapsular" class, that is, every one in which the fracture was not clearly within the limits of the synovial membrane, presented a long point running down close to the lesser trochanter, embracing the lower wall of the neck of the bone, and the pyramidal mass of columns already so often mentioned. And in this statement may also be included all those specimens which would be placed under the head of "mixed." In other words, I feel warranted in saying that all fractures of the neck of the femur are divisible into two classes: one in which the line of separation runs across the neck of the bone between the reflection of the synovial membrane and the margin of the head, the other in which the line begins close to the trochanter and runs up obliquely, and more or less irregularly, to the upper surface of the neck near the head. This long, wedge-like point is very apt to be driven into the cancellous structure of the uppermost part of the shaft, and may split or burst away several fragments of it, one of which will probably consist of the greater trochanter.

By a mechanism not materially different from that now described, fracture may be caused by any force acting upon the shaft of the femur as a lever, the head of the bone being fixed; the enormous advantage afforded by the length of the shaft must be at once apparent.

As to the production of the intra-articular fractures—those in which the neck of the bone is broken nearly or quite transversely—they are generally due, I believe, to a twist impressed upon the part. In some cases this is very

obvious, as, for example, when the bone gives way by reason of the patient tripping, or in merely turning around suddenly. Here the great leverage afforded by the length of the femur is almost doubled by the addition to it of the length of the leg; and it can scarcely be a matter of surprise that the neck of the bone should yield.

The accidents which cause these fractures may be various: falls on the feet or knees, driving the femur upward, or falls or blows upon the trochanter, in whatever direction these may come. Sometimes it is difficult to tell whether the fall is the cause or the result of the fracture, in the cases especially of old people, and when the fracture is evidently within the joint.

I may, perhaps, anticipate somewhat here, by saying that in practice the distinction is not always easily drawn between the two forms of fracture. The differential signs so clearly laid down by authors may not exist, or they may be masked by swelling, or by the obesity of the patient.

After what has been said of the mode of production of these injuries generally, it will not be difficult to see how the capsular ligament and periosteum may be only partially torn, and may sometimes even remain entire. Under but slight stress, momentarily sustained, the fibrous structures may be only stretched. If they give way at one part only, that part will correspond to the greatest separation of the bone. Such cases are by no means rare.

One instance is on record, and the specimen is preserved in the Warren Museum,¹ of partial fracture or fissure of the neck of the femur. It was taken from a man aged forty-two, who had fallen through two stories of a building, upon a hard floor. The shaft of the bone was also broken transversely at about the middle. "The fissure involves about three-fourths of the circumference of the neck, the inner anterior portion only being spared; and to a considerable extent it runs along very near to the head of the bone. It is quite closed, but there is considerable motion between the head and neck, when the head and shaft are grasped, and moved upon each other; and the fissure would undoubtedly result in a perfect fracture if much force were used."

Coulon is quoted by Holmes² as having seen "the neck of the femur fractured in straightening a diseased hip, though no chloroform was given, and the extension so gently conducted that the child did not cry."

The *symptoms* of fractures of the neck of the femur are very variable in the degree of their distinctness. Cases sometimes occur in which a mistake would be impossible, while in others the utmost care and skill cannot enable the surgeon to arrive at a positive conclusion.

In well-marked cases there is loss of power in the limb, standing and walking are out of the question, and the patient cannot even raise the knee as he lies in bed. The limb is drawn upward, or shortened; this fact being apparent at a glance, and verified by measurement made from the anterior superior spine of the ilium, or from the umbilicus, to the inner malleolus. Various forms of apparatus for making this measurement have been devised by Morton³ and others, but are scarcely available except in hospital practice, and equally accurate results may be arrived at with a good tape-line, carefully used. The patient should be laid perfectly straight, on a level surface, such as that of a hard mattress, or upon blankets folded and placed on the floor; and care should be taken to have the pelvis exactly transverse. I do not think it of any use to mark the points upon the skin, as is the practice of some surgeons, since such marks cannot but be movable. The tape should be

¹ Catalogue, p. 180, No. 1055; see, also, Hamilton, pp. 98 and 396; and Mussey, Am. Journ. of the Med. Sciences, April, 1857.

² Surgical Treatment of Children's Diseases, 1st ed., p. 244.

³ Surgery in the Pennsylvania Hospital, p. 288.

carried from the upper point down along the inner side of the knee to the lower edge of the inner malleolus, on the shortened side first, and then on the normal limb. During this procedure the coverings should be all removed, and the parts concerned completely exposed; although in women the genitals should be concealed by folding in the clothing over them.

Sometimes the shortening, scarcely perceptible at first, becomes more marked within a few days, and, if uncorrected, continues to increase until it reaches its maximum. Sometimes it is suddenly produced, a week or more after the accident, by the disengagement of the fragments. Sometimes, again, it is at first very slight, but gradually augments as the injured bone undergoes atrophic change.

Besides the measurement of the length of the limb, just mentioned, it is well to determine the distance between the trochanter and the anterior superior spine of the ilium, and so compare it with that on the sound side.

A result of the shortening, to which attention has recently been called by Allis, is the relaxation of the fascia between the trochanter and the crest of the ilium. As a diagnostic sign, it does not seem to me that this would be as valuable as an accurate measurement.

To determine the position of the trochanter several methods have been suggested. Nélaton's line is determined by carrying a tape from the anterior superior spine of the ilium, round the outer side "to the most prominent part of the tuber ischii. In the natural condition, the top of the trochanter in every position is in some part of that line."¹ Bryant drops a vertical line from the anterior superior spine of the ilium to the mattress on which the patient lies, and then ascertains the distance, measured horizontally, from the top of the trochanter to this line.

As a general rule, the foot is everted. So constant is this symptom, that the diagnosis may sometimes be settled in the surgeon's mind, in the case of an elderly patient, by this and the shortening exclusively. It would seem to be due partly to the fracturing force, partly to the weight of the foot and the natural shape of the limb, and partly to the action of the rotator muscles, the glutei especially. A number of cases, however, are upon record in which the foot, instead of being everted, was turned inward,² probably by reason of impaction of the fragments. Sometimes, as in a case under Stanley's care, recorded by Ormerod,³ the foot is neither turned outward nor inward, but remains straight, the explanation being the same. Ormerod says "the neck was broken irregularly, so that the lower portion was wedged slightly into the upper, and overlapped by it in front."

Pain is rarely absent, although it varies in degree. Sometimes it is referred to the groin, a fact explained by the derivation of the nerves supplying the hip-joint from the obturator nerve.

On grasping the thigh and leg, and rotating the entire limb, it will often be found that the trochanter describes a less extensive arc than normally. This, however, is a fact not always easy to verify, and in the case of impaction the fragments may move together, the pelvic one rolling naturally in the acetabulum, so as to be altogether deceptive. Agnew recommends that during

¹ Holmes's System of Surgery, 3d ed., vol. i. p. 1003.

² Cooper, Dislocations and Fractures, p. 131, *note*, and Case lxxxvii. p. 158. See, also, cases by Guthrie and Stanley, in the Med.-Chir. Transactions, vol. xiii. In Stanley's case the fracture "extended obliquely through the middle of the neck of the femur, but entirely within the capsule." The inversion of the foot led to a suspicion of luxation, and to attempts at reduction. "A portion of the fibrous and synovial membrane on the anterior side of the neck of the bone had escaped laceration." R. W. Smith has recorded several cases. Bigelow mentions one in his work "On the Hip," and Hamilton has seen one. Another instance has recently been reported by Dr. Conklin, of Ohio, in the Columbus Medical Journal for November, 1882.

³ Op. cit., p. 44.

this procedure the thigh should be flexed to nearly a right angle with the body. The great leverage given by the leg (the knee being of course flexed also), should not be forgotten, as the fragments may be readily displaced, and damage done.

Crepitus may be elicited by this manœuvre, and is often perceptible even if the degree of impaction be considerable; although in such a case it will be slighter and less distinct than if the fragments are freely movable upon one another. This and the preceding sign are apt to be in the same ratio of clearness.

By Maisonneuve,¹ and more recently by Levis,² it has been advised that the patient should be laid on his face, and the limb lifted up from the bed in a backward direction; if the cervix be intact, the movement will be very soon arrested. This procedure should be executed with the utmost gentleness, if at all, on account of the risk of doing mischief by separating the fragments.

Swelling and ecchymosis, although very apt to occur when the injury is the result of force applied over the trochanter, are sometimes wholly wanting when the bone has yielded to slight and indirect violence.

The *course* of fractures of the femoral neck varies greatly, according to the age and constitution of the patient and the character and severity of the local injury. In the old and infirm, there may be such a shock induced as to undermine the general health, and to lead to the extinction of life within a few weeks or months.

Occasionally the fatal result is brought about by suppuration. McTyer³ recorded the case of a woman, aged fifty-six, who fell on her side, and had afterward a slight halt in walking. She was admitted to the Infirmary, three months after the accident, for "erysipelas in the thigh." A puncture was made, and a large quantity of pus evacuated; the discharge continued, and death took place on the eleventh day. The neck of the femur was broken within the synovial membrane; "the abscess, which was situated in the thigh, communicated through the lacerated capsular ligament with the hip-joint." Reference has already been made⁴ to Hunt's case of fracture of the neck of the femur in a man aged twenty-six, who died on the twenty-second day, of pelvic abscess and pyæmia.

More commonly, in the old, the limb remains in a great degree useless, so that the patient becomes either bed-ridden or a cripple. The extent of the loss of power may be, however, but slight, especially if the fracture have been an impacted one. Even when bony union does not take place, there may be such a thickening of the capsule of the joint as to enable the weight of the body to be suspended, as it were, upon the fibrous band so formed. Perhaps the Y-ligament may add firmness to this support; and it would seem that occasionally there are adventitious bands formed, as in an instance reported by Parkman,⁵ in which there were shown "certain bands of lymph proceeding from the internal surface of the capsule to the broken surface of the upper portion or head of the bone." Morgagni⁶ states that in a case observed by Ruysch, ligamentous union had occurred between the broken surfaces, and not, as asserted by Salzmann, through the periosteum alone; and numerous specimens of this kind may be found in museums.

As to bony union between the fragments, there can be no question of its frequent occurrence in cases involving the base of the neck, close to the trochanters, or in what are commonly called extra-capsular fractures. Sometimes it is very firm, and the accuracy of adaptation of the portions of the

¹ Clinique Chirurgicale, tome i. p. 169.

² Philadelphia Medical Times, Jan. 31, 1874.

³ Glasgow Medical Journal, Feb. 1831.

⁴ See page 24.

⁵ Am. Journal of the Med. Sciences, Jan. 1852.

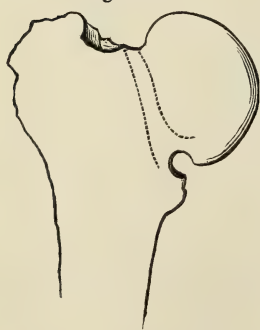
⁶ Op. cit., Letter LVI. Art. 4.

bone is such that the motions of the joint are very largely recovered. Thus Gant¹ records a case of impacted fracture of the neck of the femur, with slight shortening, in which recovery took place with firm union and a freely movable joint. I exhibited to the Philadelphia Academy of Surgery, a few years since, a man who had, when seventy-two years of age, sustained such a fracture by falling backward upon a pile of timbers; he recovered so completely that it was not apparent from his gait that any injury had ever been received. This man could lift either knee to his chin, could go up and down stairs, and in fact had no disability whatever. A very similar case was reported to Sir A. Cooper,² in 1840, by Mr. Sheppard. The fracture, in a man in his sixty-fourth year, was thought to be within the joint; yet at the end of eighteen months he was able to resume his occupation as a mail-coach guard, climbing up and down from his box "with facility, and even dexterously."

Although bony union may be obtained, and be perfectly firm, yet the motions of the joint may be impaired by either one of two circumstances: the broken surfaces may be so displaced, either by impaction or by sliding past one another, that the extent of motion is limited in one or another direction; or there may be irregular deposits of new bone about the seat of fracture, and these may come in contact with the edges of the acetabulum, or even with the surrounding portions of the os innominatum. On the other hand, there may be absorption of some portion of the fragments, leading to a shortening, perhaps extreme, of the neck of the bone, so that the head rests down against the upper end of the shaft, between the trochanters. A case was recently mentioned to me by Dr. Townsend, of Bridesburg, Pa., in which the neck of the femur was broken, and the shaft was strongly drawn upward. Union occurred between the pelvic fragment and the shaft below the trochanter, so that when the patient recovered he had not only great shortening of the limb, but its abduction was singularly hindered by the contact of the trochanter with the ilium.

The question has been often discussed, whether or not bony union could take place in cases of intra-capsular, or to speak more correctly intra-articular, fracture. A number of instances have been recorded as of this character, and from time to time others are likely to be brought forward. In 1867, I published a paper³ in which I suggested what still seems to me to be the true explanation of the majority of these cases, namely, that they are originally either wholly or in part outside of the joint, and become solidly united by bone; after which a gradual absorption of the pelvic fragment takes place, allowing the head of the bone to settle down between the trochanters. (Fig. 840.) Since the publication of these views, Professor R. W. Smith has reported⁴ to the Pathological Society of Dublin a case of bony union of a fracture, believed to have been within the capsule; and another case was reported by Dr. Senn, of Chicago, to the American Surgical Association, in 1882.⁵

Fig. 840.



Shortening of cervix femoris consecutive to fracture.

¹ Am. Journal of the Med. Sciences, July, 1866, from Med. Times and Gazette, April 14.

² Op. cit., p. 566.

³ Am. Journal of the Med. Sciences, Oct. 1867. Three cases claimed to have been seen by Fabri (Ibid. Jan. 1863), had escaped my notice, but they are too meagrely described to be of any value.

⁴ Dublin Journal of Med. Science, Jan. 1873.

⁵ Medical News, June 17, 1882.

But it seems to me that the same explanation applies in these as in the other cases.

I have seen, however, one specimen which I believe to have been unquestionably an intra-articular fracture of the cervix femoris, united by bone. It was presented to the College of Physicians of Philadelphia¹ by Dr. J. M. Adler. The patient was an old lady of sixty-five, paraplegic, who fell out of bed. Her foot was inverted, and the limb shortened; there was pain in the groin and hip-joint, and crepitus. She died five months afterward, and the bone was removed and dried. On its presentation to the College, it was referred to a committee consisting of Dr. A. Hewson, Dr. John Ashhurst, Jr., and myself. We carefully examined it, and reported unanimously that it was an impacted, intra-capsular (intra-articular) fracture, united by bone.

Let me say that some time since, when in Cincinnati, I had an opportunity, by the kindness of Dr. N. P. Dandridge, of inspecting one of the specimens reported and figured by Mussey,² and that the line of fracture was readily traceable, extending down close to the lesser trochanter, according to the rule stated on a previous page; thus proving in the case of that specimen that the fracture had not been entirely within the limits of the joint.³

Various causes have been assigned for the frequent occurrence of non-union in the intra-articular fractures of the cervix. One, which has been very generally regarded as the chief, is the want of nourishment of the pelvic fragment, which loses all connection with the vascular system except through the ligamentum teres. Another is the excess of synovia formed under the irritation induced by the injury, by which the reparative material is continually washed away from the broken surfaces. Still another, and probably not the least important, is the readiness of movement between the pelvic and distal fragments, which indeed are, in some cases, completely separated. But, however it may be accounted for, the fact remains, and bony union must be regarded as practically unattainable by any care or foresight on the part of the surgeon.

The *diagnosis* of these injuries, although sometimes clear, may present very great difficulties. It is by no means always easy to determine whether the fracture is wholly within the joint, or wholly outside of it, or partly intra-articular and partly extra-articular. When, however, the patient is old and infirm, and the violence inflicted has been very slight, such as is caused by tripping in a fold of the carpet; when the shortening of the limb is immediate and marked; and when there is great mobility of the fragments upon one another, as shown by the ready rotation of the limb, the trochanter describing a small arc—the presumption is that the separation has taken place near the head of the bone.

When the accident has been a severe one, such as a fall upon the hip; if the patient is heavy, and especially if the age is such as to make it improbable that the bones have undergone such degenerative change as to weaken their texture; when the shortening is but slight, and the fragments show no signs of free mobility upon one another, it may be regarded as probable that the fracture is outside of the joint, and that more or less impaction exists.

Prof. R. W. Smith's assertion that "the extra-capsular fracture is always accompanied by a fracture of one or both trochanters" would, if proved, afford a valuable diagnostic sign, as the mobility of the greater trochanter could in general be ascertained, and this, along with the other symptoms,

¹ Summary of Transactions, in the Am. Journal of the Med. Sciences, April, 1870.

² Am. Journal of the Med. Sciences, April, 1857.

³ The reader who desires to examine further into this subject will find the references to the supposed cases of bony union in intra-capsular fractures of the cervix femoris in my paper, before mentioned; also in Hamilton's work on Fractures and Dislocations.

would be conclusive. But, although Prof. Smith adduces a large number of cases in support of his opinion, there are many specimens of the fracture in question, in which the trochanter remains unbroken; and hence this idea cannot form a ground for diagnosis.

The other lesions with which fracture of the cervix femoris may be confounded, and from which it needs to be distinguished, are luxation of the hip-joint, and fracture of the acetabulum. Of the latter, an instance is recorded by Mr. Marsh;¹ the main symptoms were shortening and eversion of the limb, and the true nature of the lesion was only discovered upon examination after death. As to the means of distinguishing fractures about the hip from luxations of that joint, the foregoing discussion of the symptoms of fracture leaves very little to be said. I may, however, again call attention to the fact, elsewhere referred to,² that while in luxation there is limitation of passive motion in one or more directions, in fracture it is apt to be rather abnormally free. Great difficulties may, especially in persons below middle age, surround this question. In one instance within my knowledge, a man was twice examined, under anæsthesia, by four experienced surgeons, who decided that he had a fracture of the cervix femoris, but after the swelling had subsided it was discovered that the head of the femur was resting upon the dorsum ilii, and there it remained, all attempts at reduction failing.

After middle life, and in proportion to the development of the peculiarities belonging to advancing age, the chances in favor of fracture as against luxation steadily increase, until in the very old the latter lesion is almost out of the question. The few instances of the kind on record should, however, inspire caution, and prevent too hasty a judgment. Malgaigne quotes without question the observation by Gauthier of a luxation of the hip in a woman of eighty-six, and Hamilton another in a woman of seventy-three, which was unreduced when she was seen thirteen years later. Hence, in any case in which there is room for doubt, a careful and thorough examination should be instituted before pronouncing a positive opinion.

The *prognosis* in these fractures is always grave. Although life may not be destroyed, the chance is that the patient will be a cripple for the remainder of his days, and no surgeon should hold out hopes of complete recovery in such cases. At the same time, much depends upon keeping up the courage of the old and feeble, and it will often require tact and skill to do this.

As to the *treatment*, it must vary with the circumstances of each case. Sometimes all that can be done is to promote the comfort of the patient and to sustain his strength. Often the inconvenience and even distress caused by the application of confining apparatus, especially in cases of very old persons, will outweigh all the advantage derived from it. Yet there are many instances, in those who may reasonably look forward to a considerable term of life, in which suitable treatment may do much to mitigate, if not to prevent, lameness. In the former class of cases, the knee should be supported on a pillow, and the limb placed in the easiest position, with the muscles relaxed. The patient should be allowed to lie as may suit him best; sometimes a reclining chair, enabling him to sit up and lie back alternately, answers an excellent purpose. Bed-sores must be carefully guarded against by cleanliness, by frequent washing of the prominent bony points with whiskey, and by the use of India-rubber air-cushions. Sometimes these cases are complicated by dribbling of urine, especially in old men with prostatic enlargement; and then the bladder should be emptied with the catheter at stated times.

In cases of the other class, extension is called for, and may be best effected

¹ British Med. Journal, March 18, 1882.

² See p. 29.

by means of adhesive plaster, carried along the entire limb, and attached below to a cord running over a pulley and having a weight at the end of it. This weight need not be more than two or three pounds, and should never be sufficient to annoy the patient. The object is not so much to draw the limb down, as to steady it, and prevent any increase of the shortening. Sand-bags should be placed along the sides of the limb, and the foot should be supported as nearly upright as possible. By elevating the foot of the bed on bricks, the weight of the body is made to afford counter-extension. My own practice is to direct the patient, after ten days or two weeks, to sit up in bed a little while each day, the extension being kept up; thus preventing the hip-joint from becoming stiffened.

Excision of the detached head of the bone has been proposed, but I know of but one instance¹ in which such a procedure has been adopted, and in that the result was a useless limb. It seems to me that this operation could only be justified in cases in which suppuration had taken place, and that even then its advantage would be questionable. The same may be said of the operative measures proposed, and in a few instances carried out, for fastening the fragments together, and avoiding the non-union so apt to ensue after fractures in this region. Such a course would be useless in the old and feeble, and unnecessary in younger persons, in whom fairly satisfactory results can be obtained by less difficult and less dangerous means.

Fractures of the neck of the femur may occasionally be complicated with luxation of the head of the bone. Such a case was met with by Thornhill,² who effected reduction, by means of pulleys, at the end of six weeks. Tunnecliff³ has reported the case of a farmer, thirty years old, who was caught under a falling tree, and had a fracture of the cervix, the head of the bone being also displaced into the sciatic notch; reduction was accomplished by manipulation on the thirty-eighth day. Another instance was recorded by Douglas.⁴ It was observed after death in the body of an old fisherman, who had twelve years previously sustained a hurt. The head of the femur was in the groin, under the middle of Poupart's ligament, "the femoral vein and artery being to its outer side and upon it;" the neck of the bone was broken outside of the capsule. In these cases the luxation must have been first produced and then the fracture; for otherwise there would not have been purchase enough to dislodge the head of the bone.

Mr. Henry Morris⁵ recently reported to the Royal Medical and Chirurgical Society a case of impacted fracture of the neck of the femur, in an old man who had for years had an unreduced dorsal dislocation of the same thigh. Under examination the impaction was broken down, and union occurred with the limb in a much better position. Occasionally, but very rarely, the vessels suffer. Thus, Brainard⁶ mentions a case in which aneurism of the femoral artery was developed as a result of fracture of the cervix femoris produced by a blow against a wheel; the external iliac artery was successfully ligated. Robinson⁷ reported a similar case, in which an operation was proposed, but refused by the patient, who died. No autopsy could be obtained.

Separation of the upper epiphysis of the femur may be mentioned here. It is very analogous to fracture of the neck of the bone close to the head, but

¹ Howe, Med. Record, Nov. 16, 1878. In the Index Medicus for May, 1882, there is a reference to a work by Wiesenthal: Ueber operative Behandlung intracapsulären Schenkelhalsbrüche durch Excision des abgebrochenen Gelenkkopfes. Halle, 1881. I have not had access to it.

² London Med. Gazette, July 20, 1836.

³ Am. Journal of the Med. Sciences, July, 1868.

⁴ London and Edinburgh Monthly Journal of Medical Science, Dec. 1843.

⁵ Lancet, Feb. 18, 1882.

⁶ Am. Jour. of the Med. Sciences, Oct. 1843.

⁷ London Medical Gazette, June 28, 1834.

occurs, of course, only in the young, the epiphysis uniting with the neck at about the eighteenth year. Another important difference, as appears from the recorded cases, is the much greater violence generally assigned as the cause of the epiphyseal disjunction. Six instances of this lesion may be found described by Hamilton, one of which he himself saw. Hutchinson¹ met with one, and refers to two others. Stimson² quotes a case in which the diagnosis was verified by dissection. Dr. J. M. Barton has recently³ reported the case of a boy of fifteen, in which he suspected a lesion of this character, but the evidence does not seem to me to have been conclusive.

Far more may be expected from treatment, in a lesion of this kind, than in the fractures which affect the same region in advanced life. Such shortening as exists, may be corrected by extension with the weight and pulley, and the joint may be immobilized by means of a well-applied plaster-of-Paris bandage around the pelvis and thigh. This confinement may be continued, with sand-bags on either side of the limb, and the extension kept up, for two or three weeks in the case of a child; a longer confinement would be advantageous in patients beyond the age of puberty. Cautious experiments should be made at first in allowing flexion of the hip-joint, but if they are productive of no pain or irritation, more and more freedom may be accorded to the patient, until he can move the limb without hindrance; after which, with equal caution, he may be encouraged to put the foot to the ground, and to bear his weight upon it.

A number of years ago, I had a patient, nineteen years of age, who, by a fall from a very high wagon-seat, had sustained a fracture of the cervix femoris, the existence of which was verified, with the patient under ether, by Dr. Nancrede and myself. He was treated in the manner above mentioned, and in six weeks was driving his wagon again, with scarcely any perceptible lameness in walking. My belief is, that the lesion was really a separation of the epiphysis.

Fracture of the trochanter major is by no means uncommon as a complication of fracture of the neck of the bone; and it has been known to occur by itself, but the recorded instances are very few. Mr. Key's case, published by Sir A. Cooper,⁴ which occurred in 1822, was the first, as far as I know. It was that of a young girl who fell in the street, striking the trochanter against a curb-stone; the nature of the lesion was only discovered after the patient's death. Mr. B. Cooper⁵ gives an account of another case which was seen by him, and in which the diagnosis was justified by the symptoms as described, although the patient recovered, and hence absolute certainty could not be arrived at. The man's age is not stated. Stanley⁶ has reported two cases, but in regard to one at least there is room for doubt whether it was not really an ordinary extra-capsular fracture of the cervix, the trochanter also being separated. Bryant mentions one in a boy aged twelve, treated by Mr. Poland. McCarthy⁷ reports that a girl of eight, having fallen on her left side, had an abscess in the hip, and that this communicated with one within the pelvis; she had also pyæmia, with pericarditis, pleurisy, and pneumonia, and the trochanter was found detached. Roddick⁸ saw a young man, aged sixteen, who had a strain while exercising, and a few days afterward symptoms of abscess about the trochanter, which was found necrosed and separated.

¹ Med. Times and Gazette, Feb. 24, 1866.

² Op. cit., p. 496; from Bull. de la Société Anatomique for 1867.

³ Medical News, July 14, 1883.

⁴ Dislocations and Fractures of the Joints, p. 186.

⁵ Ibid., p. 187.

⁶ Med.-Chir. Transactions, vol. xiii.

⁷ Trans. of the Pathological Society, vol. xxv. London, 1874.

⁸ Canada Medical and Surgical Journal, Nov. 1875.

Hamilton¹ quotes from Clarke a case of supposed comminuted fracture of the great trochanter, with the comment that it was probably "an example of fracture of the neck without the capsule, accompanied with impaction and extensive comminution." He also candidly expresses a doubt as to an instance of the kind which he had himself recorded, and upon which he is now inclined to put a similar construction.

F. W. Warren is reported² to have shown, at a meeting of the Dublin Pathological Society, a specimen of fracture of the trochanter major, taken from the body of a male subject almost fifty years of age. "It was without history; but from the entire absence of signs of recent injury, and from the fact that the line of separation followed that of the epiphysary junction, the inference seems justified that it was really a case of epiphyseal detachment, dating back perhaps thirty years."

The *cause* of fracture of the great trochanter would seem to be invariably direct violence; and the majority of the subjects are distinctly stated to have been below the age at which this epiphysis becomes united to the shaft. In such cases it may reasonably be supposed that the separation takes place through the cartilaginoid uniting substance, but that, as in separations of other epiphyses, it may in part run through the true bone, detaching a layer of it of very irregular size, shape, and thickness.

The *symptoms* of this lesion can scarcely be confidently detailed from the scanty experience recorded. Some of the symptoms, however, of the usual fractures of the cervix must be wanting; there cannot be shortening of the limb, and in rotating the thigh the trochanter cannot describe a smaller arc than normal, but will either fail to follow the movements of the limb, or if the fibrous coverings are untorn, will behave as under normal conditions.

Pain and disability of the limb must exist, the former being aggravated by pressure on the part; but these symptoms, as well as swelling and ecchymosis, would be equally likely to attend a mere contusion. When the trochanter is broken completely away from the shaft, it will probably be drawn upward, inward, and backward, by the action of the muscular fibres inserted into it; and in such a case it will be transferred from its normal place to that occupied by the head of the femur in backward and upward luxation. Stanley, speaking of the danger of confusion between these two lesions, urges "the positive resemblance of the fractured portion of the trochanter to the head of the femur, the former occupying the same place which the latter would in dislocation; and if with these circumstances there should happen to be an inversion of the injured limb, the difficulty of the diagnosis must be considerably increased." Crepitus would of course be wanting in such a condition of things, and could only be elicited by bringing the fragment again into contact with the surface from which it had been separated.

The *diagnosis* has, perhaps, been sufficiently discussed.

As to the *treatment* of this injury, it need scarcely be said that the attempt should be made to bring back and to hold in place the fragment; but as to the best means of so doing very little is known. Sir Astley Cooper's belt and pad, although theoretically very good, would be difficult to apply in practice, and, unless accurately adjusted, might increase the displacement it was intended to correct. I think that the object could be quite as well accomplished with an ordinary compress, so arranged as to confine the trochanter in its proper position, and kept in place by bands of adhesive plaster. And if the diagnosis were clearly made out, a device, such as that suggested³ for keeping the fragment of the olecranon in place, might be employed; a double

¹ Treatise on Fractures, etc., 6th ed., p. 429.

² Dublin Journal of Med. Science, July, 1876.

³ See page 152.

recurved hook, to be driven into the upper part of the separated portion, and attached by means of adhesive plaster to the skin of the limb below.

From the slight data available, it would seem that some advantage might be gained by abducting and everting the limb, as suggested by Malgaigne, so as to make the shaft follow the fragment into the position into which the muscles are likely to pull it. It is very probable that the lameness which might be induced by the injury would not, after all, be so serious as to make it worth while to subject the patient to long and rigorous confinement.

Fracture of the lesser trochanter is not described by authors as a separate lesion, although sometimes, as in a case quoted from Guthrie¹ by Sir A. Cooper,² it is incidentally mentioned as an attendant upon other and more important injuries.

In 1874 I saw, with Dr. Cohen, an old gentleman, who had slipped on an icy pavement, and in attempting to avoid falling, had met with a hurt about the hip. He could stand, but was unable to walk, and especially to draw the knee up toward the belly, although this position, with the hip-joint flexed, was the most comfortable to him. There was no shortening of the limb, no crepitus, and no eversion of the foot; but there was pain in the groin, and tenderness at the inner and upper part of the thigh. After a time, he got about on crutches, and could even walk a few steps without them; but he never fully recovered the use of the limb. He died five or six years afterward, but no autopsy could be obtained.

I thought at the time, and still think, that in this case there was a tearing off of the trochanter minor; he was very thin, and I could feel the bone on the other side, but possibly the swelling and tenderness prevented my doing so at the seat of injury. I regret very much that the true state of the parts could not be determined by dissection, but feel that even without such completion the case is of sufficient interest to be presented for what it is worth.

FRACTURES OF THE SHAFT OF THE FEMUR are in adults very common accidents. By some authors, those which affect the bone just below the trochanters are placed in a separate class; but although, like those of the surgical neck of the humerus, they present some special features, these are not so marked that they cannot be pointed out in the course of the discussion of the general subject.

The shaft is much more frequently broken in its middle portion than near either end; and this statement holds good in regard to both sexes and all ages. Adult males are more liable to the accidents producing this injury than females or children, and hence afford a majority of the cases. Hofmokl has reported³ the case of a child, not rachitic, born with a united fracture of the femur, and I have known of more than one instance in which this bone has given way during the process of artificial delivery. When the accident is due to the use of the blunt hook, in breech presentations, the upper portion of the bone is for obvious reasons most likely to suffer.

Looked at from without, the shaft of the femur always presents a more or less marked curve, convex anteriorly, and a slighter curve convex exteriorly. Very rarely it is found to be almost straight. On examination in section, the anterior wall is seen to be thinner than the posterior, where the bony substance is massed into a very thick and strong ridge, the *linea aspera*. Partly on account of this arrangement, and partly by reason of the bone's

¹ Med.-Chir. Transactions, vol. xiii.

² Op. cit., p. 172.

³ Archiv für Kinderkrankheiten, Bd. iii. S. 370. Stuttgart, 1881.

curved shape, the direction of fractures in this region is apt to be oblique from above downward and from behind forward. A few instances are on record of almost longitudinal fracture. Thus, in the Warren Museum, there is a specimen¹ described as follows: "The upper portion of the femur, showing a recent and very oblique fracture at some distance below the trochanters; and from it a longitudinal split upwards, and through the great trochanter. Also a fracture of the neck, just above the trochanters." A specimen which is in the Lyons Museum, and photographs of which Mr. Morris showed to the Pathological Society of London,² is said to present a fracture extending "from the neck to the lower third, dividing the bone into two almost equal portions, which had united by a few narrow bands of bone." A case of very oblique, almost longitudinal, fracture in a lad, which became the occasion of legal proceedings, has been reported by Dr. Hunt.³ Spiral fractures have been sometimes observed, as well as fissures; in either case the part affected is more apt to be either the upper or the lower than the middle portion of the bone.⁴

Sometimes the bone is broken in two places, as in a specimen in the Museum of the Pennsylvania Hospital,⁵ in which "the upper fracture runs obliquely from within outward, and from below upward, about two inches below the trochanter major; the lower one being a jagged, slightly comminuted fracture about three inches above the condyles." Malgaigne mentions that in the Musée Dupuytren there is an example—the only one known to him—of a triple fracture. He does not describe it further.

The *causes* of these fractures are very various. Direct and indirect violence, and muscular action, have all been observed, the second perhaps rather more frequently than either of the others.

Cases of so-called spontaneous fracture are more common in the femur than elsewhere, by reason of the great leverage afforded by the length of the bone. One of the most remarkable of these was recently reported by Rankine.⁶ It was the case of "a child aged six years, who, as the mother reported, was simply walking across the floor, when its leg doubled up, the child falling instantly to that side." The femur was found to be fractured in the middle third. The mother declared positively "that she was looking at the child walking over the floor at the time, and that there was no stumbling or anything, but only the leg seemed to double by the mere act of walking. It may be mentioned that the child did not seem to be in the best of health, although nothing very particular could be detected about it." Another case, in a vigorous man aged thirty, is recorded by Gosselin.⁷ I have treated a man, about twenty-five years of age, who fractured the shaft of the femur in pulling on a boot; he had done the same thing previously by stepping down from a chair; there was no evidence whatever of constitutional taint or disorder.⁸ Humphry⁹ records a singular case in which a woman aged fifty-six was twice

¹ Catalogue, p. 183, No. 1074.

² Lancet, Nov. 5, 1881.

³ American Journal of the Medical Sciences, Jan. 1879.

⁴ These spiral, spiroid, cuneiform, helicoidal, or screw-like fractures, as they have been variously named by the authors who have treated of them, are certainly interesting, but I must confess I have never myself seen a specimen of the kind in the femur. Holthouse and Morris (Holmes's System of Surgery, 3d ed. vol. i. p. 1021) give a good description of them, with references to the somewhat scanty literature of the subject. From that source I derive the following: Gerdy, *Chirurgie pratique*, tome iii.; Féré, *Fractures par torsion de la partie inférieure du corps du fémur*; Raullet, *Des Fractures hélicoïdales* (Thèse), 1880.

⁵ Catalogue, p. 31, No. 1135.

⁶ Lancet, March 31, 1883.

⁷ Clinical Lectures on Surgery, Stimson's Translation, p. 188. Philadelphia, 1878.

⁸ The reader will find an interesting paper "On Fractures of the Femur in Adults, without pre-existent Osseous Disease," by Clarence Foster, in the *Med. Times and Gazette* for July 17, 1880; and another by Vallin, in the same journal for Nov. 6, 1880, taken from the *Gazette Hebdom. de Méd. et de Chir.* (Paris), 10 Sept. 1880.

⁹ British Med. Journal, June 6, 1857.

the subject of apparently spontaneous fracture of the femur; the bone on the right side giving way in May, 1855, and that on the left in March, 1857. On both occasions the affected part had previously been the seat of sharp pains. Union had taken place favorably. But reference has already been made at sufficient length to this subject, in the general part of this article.

The femur has been the seat of many of the so-called "spontaneous" fractures in cases of cancer. A remarkable instance of this kind has lately been reported by Mr. Hamilton.¹ It was that of a woman aged fifty-six, who had "a well-marked case of scirrhus," for which the right breast was removed, the wound healing well; about three months afterward, she felt the right femur give way, and fell to the ground. The curious fact in the case is that she ultimately had union, although with four inches of shortening—the latter having been due to her placing herself for a time under the care of an ignorant bone-setter. Generally, a fracture produced under such circumstances fails to unite.

Fracture seldom occurs, except as the result of direct violence, at any point near the middle of the femur. The reason of this would seem to be the fact that the mechanism in other cases is leverage, and that this can scarcely ever be applied so that just the same force shall be exerted on the two halves of the bone. Generally, there is a very great preponderance of force at one end, so that one arm of the lever is virtually much longer than the other.

The immense strain put upon the femur by this leverage is shown by the occasional instances in which even perfectly strong and well-developed bones are snapped under it. I have seen a case in which a man of remarkably robust frame, in running, caught his foot in a hole in the ground, and broke his femur in the middle third.² But besides the mere leverage, irregularly exerted as before said, there is another force, a twisting, which cannot be left out of the account, although it is extremely difficult to estimate it with any accuracy. Thus, in the last-mentioned case, the foot being arrested while the momentum of the body carried the upper part of the femur forward, the shaft of the bone was acted upon above through the cervix, while below, at the knee, the condyles were held more or less exactly transverse. Under ordinary stress, such a twist would make no difference; but as the force applied is increased, the effect of the twist is to augment in a still greater ratio the actual resistance demanded of the bone.

It can hardly be maintained that the large and powerful muscles surrounding the femur, and acting upon it either directly or indirectly, are without influence in the production of its ordinary fractures, as they certainly have an effect in keeping up its displacements when broken. But in the former case their action is accessory only, and its degree is not easy to estimate. It probably varies in different cases.

Fracture having once occurred, the fragments may act upon one another to produce still further damage; as in a case reported by Bennett,³ in which the femur gave way in its upper third, and it seemed clear that the lower fragment was driven into the upper, splitting and fissuring it. Another instance was communicated by Bryant to the Pathological Society of London;⁴

¹ *Lancet*, June 2, 1883.

² In illustration of the force exerted in such actions, I am tempted to quote from Dr. O. W. Holmes, the following passage: "Walking, then, is a perpetual falling with a perpetual self-recovery. It is a most complex, violent, and perilous operation, which we divest of its extreme danger only by continual practice from a very early period of life. . . . We learn how violent it is, when we walk against a post, or a door, in the dark. We discover how dangerous it is, when we slip or trip, and come down, perhaps breaking or dislocating our limbs, or overlook the last step of a flight of stairs, and discover with what headlong violence we have been hurling ourselves forward."—(*Atlantic Monthly*, May, 1863.)

³ *British Med. Journal*, June 26, 1880.

⁴ *Transactions*, vol. xxix. 1878.

it was the case of a man eighty-three years of age, who died on the twenty-fifth day after the accident, when it was found that the shaft of the right femur "had been clearly fractured at the junction of the middle with the lower third, and the extremity of its proximal end was driven to the extent of an inch and a half into the shaft of the distal portion; this process of impaction splitting the shaft of the distal extremity of the bone, and producing a second fracture of the bone above the condyles."

The *symptoms* of fracture in the shaft of the femur are for the most part of a very pronounced character. Pain is not always present, although it is induced by any attempt at movement, whether active or passive; but there is total loss of power. Deformity is apt to be very marked, the fragments being drawn up at an angle to one another, and the lower one generally rolled outward, the weight of the foot tending to throw it over on its outer side. Often the two broken ends are entirely separated at the anterior part, but posteriorly they are held together by the reinforcement of the periosteum by the strong intermuscular fibrous tissues attached along the *linea aspera*. This connection may be quite close, but sometimes even here the periosteum is stripped away to a considerable degree, so as to allow a good deal of play to the fragments, and admit of the occurrence of decided overlapping. Swelling quickly takes place, but from the great depth of the bone there may be but slight ecchymosis. Preternatural mobility at the seat of fracture is very perceptible; and crepitus is induced, of course, if the broken ends are rubbed together. Often a mere glance is sufficient to show the nature of the injury. The shortening of the limb, which strikes the eye at once from the position of the foot, may be verified by measurement between the umbilicus, or the anterior superior spinous process of the ilium, and the inner malleolus, as compared with that on the sound side. However carefully made, this measurement is very apt not to be absolutely correct, partly because of the mobility of the skin, and partly because of the difficulty of getting exactly the same bony points on each side. But the matter is really one of small consequence, and it is sufficient if the fact of shortening is made out. Ordinarily the difference between the two limbs strikes the eye at once, and may be from an inch to two or three inches. In one case (the reference to which has escaped me), no treatment having been instituted, the ultimate loss of length was four inches.

Cases are occasionally met with in which *both* femora are fractured, and here comparative measurement is, of course, valueless. One such, occurring to a sailor at sea, is reported by Surgeon H. Smith, U. S. N.¹ Reference will be again made to this condition of things in connection with the modifications demanded by it in treatment. Sometimes the fever is repeatedly broken at the same point, as in an instance recorded by Humphry,² in which a woman aged sixty had in 1856 the fourth fracture at the lower part of the bone, the first having occurred in 1847. Firm union took place, but only after the lapse of eighteen weeks.

Gosselin³ mentions a still more remarkable case, in which a young man of twenty had broken his left femur six times in the course of twenty months. Confinement for three months, with the use of phosphate of lime, was resorted to, and the accident did not again occur.

Fractures of the shaft of the femur are seldom attended with any serious complications. Hammick⁴ says that in simple fracture of the thigh he has never seen the large vessels wounded so as to endanger the limb; but he has once seen tetanus. "A filament of the anterior crural nerve was found

¹ Am. Journal of the Med. Sciences, July, 1865. The same number contains an account of another case, in a child aged six, reported by Dr. A. Peter.

² British Medical Journal, June 6, 1857.

³ Op. cit., p. 192.

⁴ Op. cit., p. 74.

stretched through a cleft in the bone, so tense as to resemble a violin-string. The patient had broken his thigh at sea, seven days before the arrival of his frigate in the sound."

Burr, however, has reported¹ an instance of occlusion of the femoral artery from fracture of the femur; gangrene of the leg ensued, and amputation was performed. And Weinlechner met with a case² in which the artery and vein were both ruptured, with hemorrhage and consequent gangrene; amputation was submitted to on the third day, but death from septicæmia followed.

Such lesions are much more apt to occur when the shaft of the bone is broken very low down. Thus, Travers³ relates that "a man broke his thigh; the bone protruded above the patella; at the same time a diffused aneurism of the popliteal artery was produced by a spiculum of the fractured bone penetrating that vessel, though it was discovered only on the fourth day. The femoral artery was immediately tied by Mr. Bransby Cooper, whose patient he was. The ligature came away on the sixteenth day; in another week the aneurismal swelling had disappeared, and the fracture was soundly united in six weeks." Another case is reported by Mr. B. Cooper,⁴ in which, the patient having been admitted into Guy's Hospital with compound fracture of the femur, there was so much tension of and injury to the soft parts, that it was thought unadvisable to put the limb in splints. During the night spasm came on, and the femoral artery was lacerated by a portion of the splintered bone coming in contact with it. A ligature was placed upon the vessel, and the fracture united so quickly that Mr. Key remarked of the case, that "the quickest way of producing union of fracture of the femur appeared to be by tying the femoral artery."

Sometimes fractures of the shaft of the femur are complicated with luxation of the hip, as in the case recorded by Murdoch,⁵ where the bone was broken in its upper third, and its head lodged upon the ischium; the latter lesion was only discovered after death, which resulted from hemorrhage consequent upon an operation for non-union.

Gayet is reported⁶ to have expressed the opinion that hydrarthrosis of the knee was very apt to ensue upon fracture of the femur. Ollier had seen the same in other joints, and thought it might be due to propagation of irritation through the bone. [According to Gosselin, the intra-articular effusion is due to irritation of the outer surface of the synovial capsule, by the extravasated blood which gradually finds its way downward from the seat of fracture; hence this symptom may not be observed until some hours or even days after the reception of the injury.]

The *diagnosis* of fractures of the shaft of the femur does not often present any difficulty. Yet a case was reported, and the preparation shown to the Eighth Congress of the Deutsche Gesellschaft für Chirurgie,⁷ in 1879, of amputation of the thigh in its upper part, by Langenbeck, for supposed malignant tumor, in a man aged forty-eight. There was found, however, only a simple fracture, with great separation of the broken ends, excessive growth of calus, and a distinct false-joint. No history of traumatism could be elicited. Analogous cases are said to have been cited by Langenbeck, Martini, Roser, and Kuster.

Such cases are certainly rare; yet, while there can seldom be any trouble in ascertaining the mere fact of the existence or non-existence of fracture, it

¹ Trans. of Med. Soc. of State of New York, 1873.

² Quoted in the Index Medicus for March, 1883, from the Aertzl. Ber. der k. k. allg. Krankenhaus zu Wien, 1882.

³ A Further Inquiry, etc., p. 436.

⁴ Lancet, Dec. 5, 1840.

⁵ Trans. of Pennsylvania State Medical Society, 1878.

⁶ Med. Times and Gazette, Dec. 30, 1871.

⁷ Verhandlungen, S. 30.

may be by no means easy to determine the character of the lesion or the direction of the line of breakage: and this obscurity is apt to be the greater, the further the fracture is seated from the middle of the shaft, either upward or downward. In fractures of ancient date it may be extreme. A child about three years old was some time since brought to me on account of a lameness strongly resembling that of hip-joint disease; but, on examination, I found that there had been, just below the trochanters, a fracture of the femur which had united firmly with the fragments at an angle of nearly 90° . The child had, in fact, been allowed to walk while the callus was yet plastic, and the lower fragment had tilted up the distal end of the upper.

The *course* of uncomplicated cases of fracture of the shaft of the femur is generally favorable, union occurring in six or eight weeks in adults, and somewhat earlier in children. Heydenreich¹ has reported a case in which union was firm in thirty-five days, and Henderson² one in which an oblique fracture near the middle, in a woman eighty-nine years old, had united solidly on the forty-fourth day. Lee³ saw a case of union of a broken femur in a man aged ninety-eight. False joint or pseudarthrosis has been met with, and is difficult to manage on account of the great mass of muscle, making it very hard to keep the comparatively small ends of the broken bone together. Operative interference in these cases is attended with peculiar danger; but this subject has been already spoken of in the general part of this article.

Williams⁴ has recorded a singular case, in which a man, aged seventy, sustained from direct violence a fracture in the upper part of the lower third of the femur, about half an inch above the point of entrance of the nutrient artery. Union took place with overlapping; the upper fragment was atrophied and conical, the lower presented a good deal of callus, and was of full size.

Union with deformity is of far more frequent occurrence, and, in fact, if all shortening, of whatever degree, be considered as deformity, it may be said to be universal. When the fragments are kept wholly apart, they may altogether fail to unite, but it very seldom, indeed, happens that such is the case. A much more general event is that part of the periosteum remains untorn, and bridges across the interval between the fragments, which thus become connected by means of an intermediate formation of callus. (Fig. 841.) It is astonishing how strong a bone is when united in this way, and how little inconvenience and deformity ensue, provided only that there is a parallelism of the long axes of the two fragments, and that there is no rotary displacement. Of course, however, exact coaptation is far preferable when it can be secured. I shall have to refer to this matter again in connection with the subject of treatment, and hence it need not be dwelt upon just now.

Fig. 841.

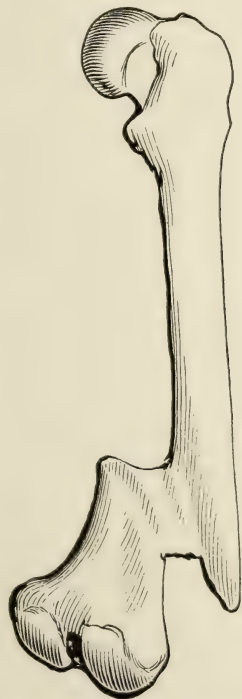


Diagram showing a femur united by a bridge of callus.

¹ Mém. de la Soc. de Méd. de Nancy, 1882. (Index Medicus.)

² London Med. Gazette, Jan. 13, 1843.

³ St. George's Hospital Reports, vol. iv., 1869.

⁴ Dublin Med. Press, April 17, 1844.

From what has been said, it will be inferred that the *prognosis* will vary according to the circumstances of each case. It is certainly better for the surgeon to be very guarded in making promises or predictions as to the result, since the patient or his friends may be greatly disappointed at even a slight and unavoidable degree of deformity. A strong and serviceable limb is in the vast majority of cases obtained, but occasionally there is a permanent halt in the gait.

The *treatment* of fractures of the shaft of the femur is a subject which has engaged the attention of surgeons for a very long time, and upon which much ingenuity has been expended. The end which has been most earnestly sought has been to devise means of making extension and counter-extension, for the purpose of overcoming the shortening which is the most obvious consequence of these injuries. Yet, by some this method has been wholly discarded, and the best results have been claimed from merely putting the limb in such a posture as to relax the muscles. At the present day, there are very able advocates for the use of lateral compression by means of solidifying bandages, to the exclusion of all direct extending apparatus. The adherents of these various plans have for the most part brought forward measurements, purporting to be accurate, of the limbs treated by them, in evidence of the completeness with which shortening was avoided. But I think that to speak of a shortening of an eighth, or even of a quarter, of an inch in the lower extremity, is a refinement beyond practical comprehension. I do not believe that ten, or even five, surgeons, examining a case independently, and without bias as to the method of treatment which had been pursued, would agree within an eighth or a quarter of an inch in their results. Hence I should decline to accept such statements implicitly, regarding them as over-precise. Practically, if a limb is in good line and free from rotary displacement, a shortening of half or three-quarters of an inch is a matter of small moment. Extension and counter-extension ought, in my opinion, to be carefully and effectively made, and the length of the limb maintained as accurately as possible, attention being given quite as sedulously to the preservation of its proper line.

It would occupy too much space to attempt to give here a full description of all the forms of apparatus which have been at various times proposed and employed in the treatment of fractures of the shaft of the femur, although the subject is really one of the most interesting in the history of practical surgery. I shall first describe the method of dressing these injuries which I myself use, and which is employed by many others, and then some of the modifications of it which may be required to adapt it to special cases. Afterward, I shall mention some other plans of treatment, and, lastly, will give briefly some historical points in regard to certain portions of the apparatus.

When a patient with a broken thigh-bone has to be transported to a place where he is to be treated, whether to a private house or to a hospital, especial care should be taken to guard against needless disturbance of the fragments. A very good plan is to take a board about six inches wide, and long enough to reach from the axilla to the foot, and to place this on its edge along the side of the patient. The limb, having been drawn out as nearly as may be to its normal length, may be surrounded with a bundle of straw, or with a folded quilt or blanket, and then bound to the board with a number of broad strips of muslin or linen, the body being also confined in the same way. If another board is now slipped under the pelvis and lower extremities, the patient can be carried very comfortably.

Arrived at the place of destination, a bed is prepared with a firm, hard mattress, perforated or not,¹ and the patient's clothes are removed. As far

¹ See page 56.

as possible, the exact seat of fracture is now determined, and the amount of shortening is ascertained by measurement. A strip of good adhesive plaster, about three inches wide, and long enough to reach from the seat of fracture down one side of the limb to four inches below the heel, and up along the other side of the limb to the point of fracture again, is well warmed and applied, leaving a loop of eight inches below the sole of the foot. In this loop is placed a piece of thin board three inches square, and close to it, at either side, a small slit is cut in the plaster, through which a cord or strip of bandage may be passed. Three or four transverse strips of adhesive plaster, or a roller, may be applied to keep the longitudinal strips in exact contact with the skin. A pulley is now placed at the foot of the bed, either on a tripod with one long foot, extending under the bed, and two at right angles to it, or on a rod attached to the bedstead frame with a clamp. An ingenious apparatus for attaching the pulley has been devised by Dr. Sheppard.¹ One form of it is intended for cribs or beds with high foot pieces, the other for the ordinary iron bedstead in use in hospitals. I have sometimes screwed the pulley into the foot-board when the bedstead was so made. In the case of some iron bedsteads, a pulley may be made with a spool and a piece of wire, the latter being run through the former, and then bent up and curved into two hooks to catch on to the bar of the bed-frame.

The patient is now to be placed in the bed, the foot of which is elevated a few inches by means of a couple of bricks; the cord is passed over the pulley, and the surgeon proceeds to make extension and to adjust the fragments. Sometimes the services of assistants are required in doing this, and occasionally anæsthesia must be induced. If the limb be a very muscular one, and the displacement great, one assistant may grasp the foot and another the upper part of the thigh; the force used must be very gentle and gradual, and, while it is exerted, the surgeon carefully handles the fractured part, and coaxes the broken ends into their normal relation. Sometimes, in old people, or in persons of no great muscular development, the adjustment is readily made, and as easily kept up by moderate traction. But in the strong, or in those whose nervous systems are excitable, a good deal of power has to be exerted. The weight to be used depends greatly upon these circumstances; sometimes it is but small—perhaps two or three pounds—and again it may require ten or twelve pounds to overcome the muscular resistance. One, two, three, or four bricks may be thus used, or bottles of sand, or regular weights placed in a frame; the latter device is adopted in some hospitals.

Sand-bags, to give lateral support to the limb, are of great service; they are made of muslin, are long enough to reach, one from the heel to the perineum, the other from the heel to above the crista ilii, and should be ten or twelve inches in circumference. They ought not to be too tightly stuffed, but should be capable of adaptation to the outline of the limb.

Whenever the patient is restless, or if there is a tendency to angulation of the thigh forward or outward, or both (it very seldom bends inward or backward), one or more “coaptation-splints” may be employed. Binder’s board or felt answers best for this purpose, a piece of suitable size being softened in hot or cold water, and moulded to the normal shape of the thigh; after which it is to be carefully padded, and applied with a roller, or with three or four wide adhesive strips.² If the foot shows any tendency to displacement, whether outward or inward, this must be carefully corrected, as it indicates rotation of the lower fragment; and the proper position must

¹ Medical News, Jan. 7, 1882.

² The plaster should always be cut for this purpose in the length of the piece, and not across it, lest it should yield and stretch.

be secured by a loop of bandage around the foot, fastened to the sand-bag on the side opposite to that toward which the foot inclines.

Certain details must be attended to in making all these arrangements, in order to the effective working of the plan. The adhesive strips must be smoothly fitted, and not allowed to wrinkle, lest the skin should be irritated; the circular pressure should not be tight enough to obstruct the return of venous blood along the limb; the pulley must be placed at the proper height, and exactly in the line of the long axis of the limb. Should the constant pressure on the heel give rise to any soreness, a mass of carded wool or cotton may be placed a little above, so that the limb may rest on a different point; it is better, however, to guard against any such trouble by protecting the skin with a patch of soft kid spread with soap plaster. The proper adaptation of the weight to the necessities of each case is a matter of much consequence.

It will be perceived that in this plan of treatment the counter-extension is exerted by the weight of the body, by reason of the elevation of the foot of the bed, a device credited by Hamilton to Dr. Van Ingen, of Schenectady. The weight and pulley, distinctly described by Gui de Chauliac in the fourteenth century, was brought forward in modern times by John Bell, in 1801, and in this country, in 1824, by Dr. Luke Howe, and again in 1829, by Dr. Daniell, of Georgia.¹ Its most prominent advocate, however, was the late Dr. Gurdon Buck, of New York, whose name has been generally attached to the method since he revived it in 1861.² To show how thoroughly developed it had formerly been, however, I may perhaps quote the following passage from Le Clerc:—³

“To hinder the Patient from turning cross and sliding down toward the Feet of the Bed, you must plant a Stake into the Floor, underneath the Bed, and pass it through the Matting and Bedclothes, so that it may be between the Patient's Legs. This ought to be as thick as the small of the Arm, and covered with some Stuff or other, that it may not hurt the Patient. And for greater security, let it be ty'd with an equal Girth to the Patient's Thigh above the Knee; and let each Branch or Tail of the Girth pass on each side the Knee, exactly on the middle, and over two Pullies (fastened at the end of the Bed's Feet), and at the end of them let there be two Weights suspended to draw the Thigh, and keep it in a streight Posture. The Thigh must be wrapt round with a Bolster in the Place where the Girth is, that it may not hurt it.”

When the fracture is very high up, just below the trochanters, there is apt to be not only the drawing upward of the lower fragment, but a tilting upward and forward of the upper one, by contraction of the psoas and iliacus muscles. Perhaps this fragment is also rotated outward by the glutei and other rotator muscles at the back of the hip; but I have never seen this distinctly. Under such circumstances there is so little purchase upon the upper fragment, that it is apt to remain in its abnormal position in spite of every effort to bring it down; and the result is that when union takes place the limb is not only permanently shortened, but deformed and seriously disabled. I believe that in such a case the only resource is to make the lower fragment follow the upper, by raising the knee and flexing the whole thigh upon the pelvis. This may be done by means of the double-inclined plane in some form, or perhaps even by the single inclined plane, as the latter would produce no tension upon the muscles of the front of the thigh. The double-inclined plane is merely a framework, generally hinged so that the angle can be

¹ The reader will find an excellent article on the history of this subject, by Dr. E. Hartshorne, in the *American Journal of the Medical Sciences* for April and July, 1869.

² *American Medical Times*, March 30, 1861.

³ *The Compleat Surgeon*, etc. London, 1727.

changed at will; one part of it is intended to support the thigh, while the leg rests upon the other, the angle occupying the bend of the knee. Extension may be made by means of a pulley attached either to the apparatus itself, a frame being added for the purpose, or to a standard fixed at the foot of the bed.

The single inclined plane, as its name imports, is a board inclined at an angle, upon which, properly padded, one or both of the patient's lower limbs may rest. Extension may be made by means of a pulley fixed at the upper end of the board. One objection holds against both these forms of apparatus; there is much difficulty in preventing the patient from working his body up on to the inclined plane, so as to neutralize its effect more or less completely. Possibly this object might be accomplished by having a perineal block, or a well-rounded upright arranged at a suitable point. But it would perhaps be better to have recourse to one or other of the suspensory splints to be presently described.

Dr. Swinburne, of Albany, advocates¹ the treatment of fractures of the shaft of the femur by simple extension, using a perineal band attached to the head of the bed, and fastening the lower part of the limb to the foot of the bed, by means of adhesive plaster and a cord. Without disputing Dr. Swinburne's statements as to the results obtained by him in this way, I cannot but think that the less rigid methods are at the same time more comfortable to the patient, more adaptable to the varying circumstances under which fractures occur, and more likely to be satisfactory in the hands of most practitioners.

Plaster-of-Paris bandages were strongly recommended a few years ago by Dr. Sands,² of New York. They were applied during complete extension, and sometimes under anæsthesia. Whether acknowledged or not, the efficacy of this method must have largely depended upon the extension made against the swell of the leg below the knee, and the counter-extension against the upper portion of the thigh; and the lateral compression must have been at once lost if the thigh itself diminished in size, as it naturally would do from total inaction. My own experience of this plan is limited to a very few cases in children, in which it afforded good results. It seems to me that here, where there is but slight muscular power to be counteracted, and the small size of the bone makes the leverage on the fragments but trifling, the plaster-of-Paris or other solidifying dressing, especially the silicate-of-potassium, is much less objectionable than in the case of adults. Hamilton, however, holds the opposite view. He says: "If I have been unable to give my approval to the treatment of fracture of the shaft of the femur in adults with plaster of Paris, or to any other form of immovable dressing, I am still less able to give it my approval in fracture of the same bone in children." He then relates a case of gangrene in a boy four years old, treated on this plan; but, according to the account, there was unpardonable neglect on the part of the surgeon, and nothing is proved against the treatment if carried out with ordinary skill and judgment.

The method devised by Dr. Nathan Smith, and improved upon by his son, the late Dr. Nathan R. Smith, of Baltimore, has had a wide popularity in this country, especially in the Southern States. As at first made, the apparatus consisted of a wooden splint, cut so as to fit along the front of the entire limb, from the groin to the toes, the hip and knee being each flexed to about 135°. To the under side of this splint the limb was carefully bandaged, and then slung by means of two staples driven into its upper face, one

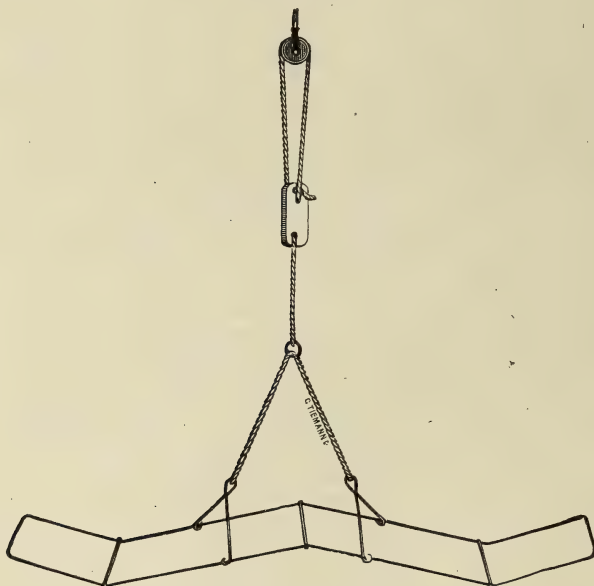
¹ Treatment of Fractures of Long Bones by Simple Extension. Albany, 1861.

² New York Medical Journal, June, 1871.

above and the other below the knee. By changing the point of suspension, a more or less considerable degree of extending force was applied to the limb, the weight of the body upon the bed giving the counter-extension.

Afterwards, this splint was modified by substituting for the wooden splint a wire frame, suspended by means of wire loops. One advantage of this is that it may be bent so as to suit limbs of various lengths. The cord attached to the splint runs through the loop of another cord, which passes over a pulley fastened in the ceiling, or in a frame over the bed; and this latter cord is passed through what is known as a tent-block, by means of which it may be tightened up or let out, so as to raise or lower the limb at pleasure. (Fig. 842.)

Fig. 842.



Smith's anterior splint for treatment of fractured thigh.

By the late Dr. Hodgen, of St. Louis, a somewhat similar splint was used, but, instead of being bandaged to it, the limb was suspended in it by means of strips of muslin, so that it formed a sort of cradle. (Fig. 843.)

With both these forms of apparatus good results have been obtained in a very large number of cases. Yet in one instance seen by me, that of a man treated by an experienced surgeon, and an enthusiastic advocate of Smith's method, the fragments had united at an angle backward, and such pressure had been made upon the sciatic nerve as to give rise to very serious symptoms, only partially relieved by an operation.

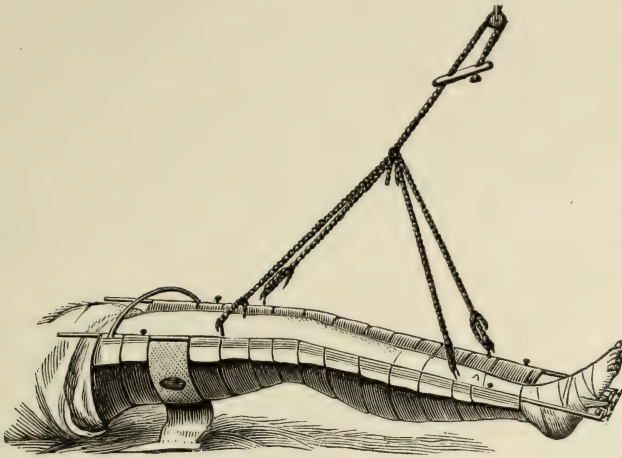
I may mention that Dr. J. R. Taylor, of New York, has recently¹ published an account of a "saddle" attached to an iron brace, and fitting into the perineum, for the purpose of making counter-extension, extension being made by means of a coiled spring. Dr. Brownrigg, of Tennessee, has described² an apparatus of his own, in which counter-extension is made by means of a

¹ Journal of Am. Med. Association, Sept. 1, 1883.

² Trans. of Mississippi State Med. Association for 1881, quoted in the College and Clinical Record for August 15, 1883.

jacket of stout muslin. Neither of these plans seems to me to possess any advantages over other methods more generally known.

Fig. 843.



Hodgen's suspension splint for treatment of fractured thigh.

Mention has already been made, in a previous part of this article, of certain forms of apparatus known as fracture-beds. These contrivances, of which the best known perhaps were Earle's, Amesbury's, Crosby's, and Burge's, were mostly on the principle of the double-inclined plane, but some of them were arranged for making extension with the limb straight. They were all complicated and expensive, and liable, when used in hospitals, to become infested with bugs. At the present day, I think that they may be said to have been abandoned.

Vertical extension has been recommended in cases of children, by Kümmel,¹ who applies adhesive plaster in the manner before described, and keeps the leg in the vertical position, with the corresponding side of the pelvis suspended by means of a cord fixed to the loop of plaster, and either attached above to some object over the bed, or slung over a pulley, with its free end supporting a weight. A curious effect of this treatment, in female children, is the occurrence of vaginal catarrh, which, however, soon yields to appropriate measures when the extension is no longer kept up. Bryant recommends vertical extension of both the sound and the injured limb.

A few words may now be said as to the development of the present methods of treating fractures of the shaft of the femur, and especially in regard to certain points.

Benjamin Bell² describes an apparatus, invented, he says, by Gooch, and improved by Aitken, "which promises to be of the greatest utility in oblique fracture of the thigh." It consists of two leather straps, one buckled around the upper part of the thigh, the other around the lower part; "two or three steel splints, connected with the straps, pass from one to the other in such a manner, that by means of them the straps can be forced asunder," thus making extension and counter-extension. If such an apparatus could be borne by the patient, it would seem that there would be great danger of undue pressure, with serious consequences.

Desault's splint extended from the crista ilii to the sole of the foot. It was

¹ Am. Journal of the Med. Sciences, July, 1882; from Berl. klin. Wochenschrift, No. 4, 1882.

² System of Surgery, vol. vi. London, 1788.

notched at either end, and the upper and lower turns of the bandage confining the limb to it were cast through these notches, so as to make an imperfect and inefficient extension and counter-extension. Physick lengthened this splint both ways, extending it up into the axilla, and downward beyond the foot; he also contrived a gaiter to be placed over the ankle, in place of the figure-of-8 bandage previously employed, and introduced the perineal band, afterward padded by Coates, for counter-extension.

Hutchinson added a block on the inner side of the long splint, below the foot, over which the extending band passed, thus bringing the force into line with the axis of the limb.

The introduction of adhesive plaster for securing the extending band to the limb, an invention the paternity of which has never been satisfactorily established, but which is certainly of American origin, was a great step in advance. By Gilbert¹ the use of the same material for counter-extension was strongly advocated.

Yet the extension and counter-extension, however carefully made, were apt to become relaxed, and various means were tried with the view to make them constant. I myself employed an India-rubber "accumulator;"² and the same idea was subsequently brought forward by Buckstone Brown³ and others in England. It was not, however, until the revival of the old weight-and-pulley extension that the problem was solved; although, indeed, the suspension splint of Dr. Nathan Smith, before mentioned, may be regarded as capable of answering the same end.

In the foregoing slight sketch, many things have been omitted which would deserve description in a history of the development of the treatment of these fractures. Such are, for example, the inside splint of Physick's apparatus, and the splint-cloth by which it and the other splint were connected; the various forms of apparatus in which it was attempted to "make the sound limb act as a splint for the injured one;" the different arrangements of screws for making extension; and the perineal block for counter-extension. All these devices have been so completely superseded that it seems to me needless to enter into detail with regard to them.

After the descriptions now given of elaborate contrivances for the treatment of fractures of the shaft of the femur, and the importance evidently assigned by surgeons to the prevention of shortening, the reader may well be surprised to know that there have been advocates of the use of a simple roller bandage in these cases. This plan, which is a good deal more than a step beyond that with the plaster-of-Paris or starched bandage, was first proposed by an English surgeon named Radley. Dr. Dudley,⁴ of Kentucky, claimed great merit for it, but without succeeding in gaining for it the favor of the profession at large. It would certainly be a difficult matter to convince a jury, if a dissatisfied patient should seek for damages in a case so treated, that due care had been exercised to obtain the best possible result.

Bryant, however, tells us that, in St. Bartholomew's Hospital, both Paget and Callender were in the habit of treating all cases of fracture of the shaft of the femur, in children, without splints or other apparatus; "the child being laid on a firm bed, with the broken limb, after setting it, bent at the hip and knee, and laid on its outer side." Bloxam⁵ makes a similar statement.

It may serve as an additional illustration of the diversity of views that may be held on practical subjects, if in contrast with those given on the fore-

¹ Am. Journal of the Med. Sciences, Jan. 1858, and April, 1859.

² Ibid., July, 1862.

³ Lancet, Oct. 10, 1874.

⁴ Am. Journal of the Med. Sciences, Nov. 1836; from Transylvania Journal of Medicine, etc., April, 1836.

⁵ St. Bartholomew's Hospital Reports, 1867.

going pages, as to the necessity of extension and counter-extension in the cases in question, I quote the following: Winchester¹ has advanced the opinion that muscular contraction "is, if rightly understood, a natural power of inestimable value, supplying the exact amount of forcible contact between the broken surfaces necessary to excite healthy reparative action in the most speedy and perfect manner, accurately adjusted to the functional capacity of each individual case."

When union has taken place with the *fragments in bad position*, in fractures of the shaft of the femur, the correction of the deformity is highly desirable, since, if left to itself, it entails upon the patient a lameness which not only is unsightly and mortifying, but may be a very serious hindrance to his gaining a livelihood. Generally, the best procedure in such cases is forcible refracture under anæsthesia. Numerous instances of this kind have been recorded. Norris² gives references, and more or less of detail, in regard to some twenty-five cases, all but three of which were successful. One, operated on by Bontecon, is recorded among the experiences of our late war.³ Fayrer⁴ gives two, in one of which the bone was broken at two points—at the middle and in the lower third. The patient, an English boy fourteen years of age, had met with his accident at sea. Both cases did well. Buck⁵ has recorded five. A very remarkable case of multiple fractures, one of which, in the femur, united with deformity and was corrected by re-fracture, is recorded by Tiffany.⁶ I myself had occasion, some years since, to rectify a fractured femur in a boy nine years old, which had been badly treated in the country, and had united with marked overlapping as well as slight angle outward; the callus gave way readily under ether, and the little fellow recovered so as to walk without any perceptible limp. It is well to bear in mind that in conducting a procedure of this kind a good deal of force may be saved, by not only bending the bone, but giving it a slight twist also. Extension should be cautiously made in these cases, lest if it be suddenly and too strongly effected, damage should result to the soft parts, and especially to the vessels. I have seen death caused in this manner.

Subcutaneous osteotomy may sometimes be resorted to with advantage, as in a case reported by Verneuil,⁷ this plan being preferable when the bone is affected near a joint, or when the injury is of such ancient date that union is probably very firm. The details of the operation are much the same as when it is practised in other cases, and the after-treatment does not differ materially from that of accidental fractures. Resection through an open wound, a procedure attended with much greater risk, was many times practised, and with a considerable degree of success, by the older surgeons.⁸ It is now almost wholly abandoned in favor of the improved method just mentioned.

Occasionally, when the callus has not yet become thoroughly solidified, it may be bent into proper shape by firm but gentle pressure applied by means of well-padded splints and compresses, or by bands attached to the bedstead. A case so treated with success at the tenth week, extension and counter-extension being also used, has been reported by Michener.⁹

¹ Lancet, Aug. 22, 1863.

² Contributions to Practical Surgery, pp. 112 *et seq.*

³ Med. and Surg. Hist. of the War of the Rebellion, Part III., Surgical Volume, p. 651.

⁴ Indian Medical Gazette, March 1, 1872.

⁵ Transactions of N. Y. Acad. of Medicine, 1855.

⁶ Trans. of Medical and Chirurgical Faculty of Maryland, 1874.

⁷ Bull. de la Société de Chirurgie, 5 Déc. 1882.

⁸ See Norris, *op. cit.*

⁹ Am. Journal of the Med. Sciences, Jan. 1848.

Compound fractures of the femur are always of serious importance, involving a good deal of shock, and presenting sometimes great difficulties in their treatment. When amputation is not indicated, the surgeon has to choose, among the various plans already described, the one which seems best adapted to the circumstances of the case. Often the plaster-of-Paris bandage, fenestrated so as to give access to the wound for the purpose of dressing it, and combined with suspension, presents great advantages. But in the majority of cases, the ordinary arrangement for extension, by the weight and pulley, will answer quite as well, allowing the wound to be dressed and the limb completely supported. I believe this method, carefully carried out and properly watched, to be the best, except in cases of very restless patients, as for example those who have delirium tremens; for such the plaster of Paris, with moulded splints, may be temporarily employed with great benefit. Much depends upon the situation, size, and depth of the wound; and no general rules can be laid down which shall cover the various conditions presented by even a small number of cases.

Fractures of the lower portion of the shaft of the femur are by no means as frequently met with as those higher up in the bone. They have, in most of the recorded cases, affected adult males. Opinions have varied as to their causes; Sir A. Cooper says¹ that they happen "when a person falls from a considerable height upon his feet, or is thrown upon the condyles of the os femoris with the knee bent." Hamilton concurs with him; but Malgaigne says, "These fractures seem to me to be chiefly produced by direct causes." Probably the experience of different surgeons, or of the same surgeon at different times, may differ in regard to this point as upon many others. Malgaigne had seen only two cases from indirect causes, but seven from direct. Among the former cases is perhaps included one previously published by him,² to which, however, he makes no reference in his work; the fracture was due to rotation of the knee in an attempt to reduce a luxation of the hip-joint.

However produced, these injuries present very various conditions, differing materially from those of other portions of the bone. At its lower portion, the femur broadens toward the knee, and just above the condyles swells out quite abruptly. Its cancellous structure resembles that of the lower portion of the radius, except that the downward direction of the lamellæ is more distinctly marked; and I think that sometimes the "cross-breaking strain" must be admitted as the true mechanism of its fractures also.

Generally, the principal direction of the fracture is obliquely downward and forward; but Hamilton mentions an instance in which it ran downward and backward, and in which gangrene of the foot occurred, apparently from pressure of the lower end of the upper fragment upon the vessels.

In one case, recorded by the same author, both femora were broken just above the condyles, by a fall from a fourth-story window, the patient alighting upon his feet.

A very singular specimen, in the Museum of the Pennsylvania Hospital, is thus described:³ "An oblique fracture, which commences at the linea aspera, about six inches above the condyles, and extends spirally inward and downward, completely circling the bone until it reaches within an inch of the condyle. The beginning and end of this line of fracture are united by two other lines of fracture extending upward from the lowest point until they reach the upper end of the spiral fracture. These have separated a bony fragment of the

¹ Dislocations and Fractures of the Joints, p. 244.

² Gazette des Hôpitaux, 15 Fév. 1838.

³ Catalogue (Supplement), p. 37, No. 1141¹⁵.

outer part of the shaft from the remainder, and thus completely severed the condyle-portion from the upper part of the bone." The patient, a man aged fifty-nine, had fallen from the height of a ladder. Another specimen in the same museum,¹ taken from a man aged thirty-five, who had also fallen from a height, shows a fracture about two inches below the trochanter major, besides "a jagged, slightly comminuted fracture about three inches above the condyles."

Sometimes, as in two cases recorded by Hamilton,² the long anterior point of the upper fragment projects so as to give trouble; in one of Hamilton's cases resection was required in order to effect reduction. Spence³ has published an account of a very similar case, the sharp point of the upper fragment projecting, covered merely by the skin, and with the patella apparently locked between it and the condyles. Reduction was attempted in vain, and the patient died on the fourth day, having sustained other grave injuries. It was then found that the bone had penetrated through the vastus externus and crureus muscles, and the edge of the tendon of the rectus, on dividing which transversely, reduction became possible. The condyles were found to be separated and comminuted.

Occasionally, the lower fragment is tilted down backward, as mentioned by Boyer, and observed much more recently by Erichsen, Bryant, and others; the displacement is ascribed by these surgeons to the traction exercised by the gastrocnemius muscle, which, it has been proposed, should be relaxed by division of the tendo Achillis. Three cases so treated have recently been placed upon record by Treves.⁴ I believe the cause of this rare displacement to be the upward pull of the muscles at the back of the thigh, forcing the lower fragment against the upper, by which it is again pressed backward.

I have cited from Hamilton a case in which the circulation was interfered with by the pressure of one fragment upon the vessels; Laurent⁵ quotes a case in which a popliteal aneurism was thus developed, necessitating ligature of the femoral artery. Injury to the peroneal nerve from like cause has lately been reported by Lauenstein.⁶

The *symptoms* and *diagnosis* of fractures of the lower part of the shaft of the femur need hardly be dwelt upon at much length. Pain, helplessness of the limb, swelling, deformity, and crepitus may be looked for. The main difficulty will be to determine the exact extent and direction of the lesion of the bone, and whether or not it involves the joint. For it must be remembered that even if an arthritis be not set up, there will still very probably be some effusion, and that this, along with the rapid swelling of the neighboring soft parts, will obscure the precise condition of the bone. I think that the degree of lateral mobility of the leg upon the thigh (the real point of motion being, however, above the knee) may be, to some extent, relied upon as indicating the state of the condyles; if it is very free, they have probably suffered. Anæsthesia should always be induced for the purpose of making this examination, which should be cautiously and gently conducted; and if the question is not readily settled, it is far better not to be

¹ Catalogue, p. 31, No. 1133⁵.

² Op. cit., p. 489.

³ Am. Journal of the Med. Sciences, July, 1848, from Monthly Journal and Retrospect of Medical Sciences (Edinburgh), May, 1848.

⁴ British Med. Journal, Feb. 17, 1883.

⁵ Op. cit., Obs. XXI. p. 36.

⁶ The quotation is thus given in the Index Medicus for February, 1883; Bruch des Oberschenkels oberhalb der Condylen, Dislokation des unteren Fragmentes nach der Kniekehle, mit Verletzung des N. peroneus; Befreiung des Nerven durch Resektion des vorspringenden Knochenfragmentes (Fracture of thigh just above the condyles, displacement of the lower fragment toward the ham, with injury to the peroneal nerve; freeing of the nerve by resection of the projecting portion of the bone.) Centralblatt für Chirurgie, Leipzig, 1882. I have not had access to the original account of this case.

too curious, but to assume that the condyles are involved, and to act accordingly.

The *treatment* of these injuries consists, first, in allaying inflammation by the ordinary means, keeping the joint immovable by placing it on a well-padded back-splint, and employing extension by the weight and pulley from the very outset. After all swelling has subsided, and the parts are again in a healthy condition, the limb may be laid on a pillow, and the extension kept up until the fourth or fifth week, when passive motion may be very carefully tried. Union generally occurs favorably, and, in many cases, a perfect recovery has ensued. Yet it must not be forgotten that there are chances of grave constitutional disturbance, and that in all injuries of large bones, especially in the neighborhood of joints, there are risks which cannot safely be ignored.

SEPARATION OF THE LOWER EPIPHYSIS of the femur is a rare accident, although perhaps it sometimes occurs without being recognized. It belongs, of course, to the period of life in which consolidation of the shaft has not yet occurred, that is to say, before the twentieth year (sometimes as late as the twenty-fifth). As far as I know, in all the recorded instances the patients have been males, and none of them have been over sixteen years of age.

The epiphyseal line is just above the boundary of the knee-joint, and when a separation takes place exactly through it, that cavity will not be involved, although it may become so secondarily. Holmes says:¹ "A reference to such of the published cases of 'separation of epiphysis' as are accompanied by anatomical examination, will satisfy the reader that most of them have been of this nature, viz., injuries in which the line of fracture has been close to the epiphyseal line, and generally, in all probability, corresponding with it in more or less of its extent; but accompanied with fracture in almost all cases, and, therefore, as Nélaton has truly observed, presenting identical symptoms with those of fracture." Sometimes, as in a specimen figured in the work just quoted (Fig. 43, p. 261), another line of breakage extends down between the condyles.

The cause of this injury has been in almost every case, I believe, indirect violence. Madame Lachapelle is quoted by Malgaigne as having seen the lower epiphysis of the femur and the upper one of the tibia separated at once by traction on the foot in aiding delivery. Coural² has observed in a boy of eleven years, whose leg was buried in a hole up to the knee, while his body was thrown forward, a separation of the femoral epiphysis; the upper fragment was carried backward, and on proceeding to amputation, which became necessary, the condyles were found in front of the shaft, and so tilted that the articular surface was directed forward. In several³ cases the injury was the result of entanglement of the leg in the spokes of a wheel. Robson⁴ has reported three cases. In one, in a boy of fifteen, hurt in a colliery accident, the lower end of the diaphysis projected into the popliteal space, tightly stretching the large vessels and nerve; in another, in a boy of six, the same deformity was observed; and in both, amputation was necessary. In the third, in a boy of fifteen, caught in a belt and carried around a shaft, there was the same displacement; union occurred, and excision of the knee was ultimately performed with success. In the Museum of the Pennsylvania Hospital,

¹ Surgical Treatment of Children's Diseases, first ed., p. 259.

² Fontenelle, Archives Générales, Oct. 1825.

³ One seen by Hamilton, and two quoted by him. Callender published another in the St. Bartholomew's Hospital Reports for 1873.

⁴ Liverpool Medico-Chirurg. Journal, July, 1883.

there is a specimen¹ of separation of the condyloid epiphysis, along with transverse fracture in the middle third of the bone, in a boy run over by a railroad car; also another of the former lesion only, without history.

Even in this small list of cases, the course and results presented a marked variety. Sometimes amputation became necessary, once excision; in Hamilton's case there was ankylosis of the knee-joint, and some shortening of the limb. Callender's patient did much better; union took place in six weeks, and sixteen months later there was no sign of atrophy. Another very favorable result occurred in a case treated by Puzey.² A boy aged sixteen was playing leapfrog, and alighted with his legs farther apart than usual; he fell, and was taken to the hospital with one leg at an angle of about 130° with the femur—looking, it is said, like genu valgum. Under ether, the joint was found all right. "The lower end of the thigh was now steadied, and by gently pushing the leg toward the middle line, the limb was straightened, and in so doing there was clearly felt the soft crunch and crepitus which is generally noticed in straightening out a greenstick fracture; further examination made it evident that what had occurred was a separation of the condyloid epiphysis, not quite complete at its upper aspect." Eight months after the accident, this patient was seen again, with a good straight limb and perfect movement of the knee-joint.

As to the *diagnosis* in these cases, very little can be said. The age of the patient, and the characters of the fracture—its want of obliquity, its nearness to the joint, and the smoothness of the fragments—will be the chief points to be relied upon in distinguishing this lesion from ordinary supra-condyloid fracture.

The *treatment* must consist in thorough reduction, and then in placing the limb at complete rest in an easy position, especial care being taken to prevent eversion or inversion of the foot. Extension may be called for if synovitis of the knee should ensue, but need not be as energetically made as in fracture of the shaft. Minute directions need hardly be given as to the means of following out this course, as they do not differ from those employed in other cases.

FRACTURES OF THE CONDYLES OF THE FEMUR are not very seldom met with as the result either of direct violence, as from railroad or machinery accidents, or of indirect, as from falls on the knees. They generally occur in male adults, and present numerous varieties according to the seat and direction of the fracture, the amount of bone involved, the degree of comminution, and the severity of the damage done to the soft parts.

The majority of these injuries affect both condyles, and many of them are T-fractures, the bone being broken across transversely, and the lower fragment split down into the joint. I shall speak first of fractures of this kind, and afterward of those which concern one condyle only.

Sometimes the transverse fracture is quite low down, sometimes much higher. Thus in the pathological cabinet of the New York Hospital there is a specimen³ "from a man who had had his right knee jammed between the side of a ship and a box of two tons' weight, a few days previous to the amputation of the thigh. The shaft was fractured very obliquely a couple of inches above the condyles, the inner one of which, moreover, had been crushed inward toward its fellow, and was traversed by several gaping fissures, which incompletely separated it into several fragments." Another⁴ is described as follows: "Fracture of the femur, four inches above the knee, accompanied

¹ Catalogue, p. 31, No. 1132.

³ Catalogue, p. 97, No. 177.

² British Med. Journal, Oct. 21, 1882.

⁴ Ibid., p. 98, No. 181.

by a separation of the two condyles from each other by a line of fracture up at right angles into the one first named. The condyles have united by porous bone situated between their opposed surfaces, while the fracture of the shaft has not united at all, owing, as was found on dissection, to the interposition of a portion of muscle between the fragments."

In the Museum of the Pennsylvania Hospital, there is a specimen¹ showing a transverse fracture an inch and a half above the joint, and a longitudinal fracture completely separating the condyles from each other. In this case the patient, a man, aged nineteen, was caught between two railroad cars; there was great contusion about the knee, and the popliteal artery was ruptured, necessitating amputation.

Again, in the Warren Museum, there is a specimen² with the following description: "An oblique fracture just above the condyles; and a second between these two into the knee-joint. The upper fragment is drawn downward in front of, and two inches below, the knee-joint; its pointed extremity being far advanced in the process of separation, and showing finely the contrast between the living and dead bone. A considerable quantity of new and soft bone connects this upper fragment with the shaft above the inner condyle. From an intemperate man, aged thirty-seven years, who slipped and fell with the whole weight of his body upon this limb. On entrance into the hospital (December 20, 1844), there was a shortening of two or three inches. Considerable swelling and emphysema about the knee, and a protrusion of the upper fragment nearly an inch, with great pain and considerable bleeding. The fracture was reduced, but the bones could hardly be kept in place; and on the third day, the extension being discontinued on account of the pain and swelling, the limb was simply laid in a fracture-box. Suppuration and sloughing followed. February 5, the limb was much shortened, and the upper fragment seemed to have penetrated the knee-joint beneath the patella. On the 11th of March it protruded below this bone, and on the 11th of April the man died."

Occasionally there is scarcely a distinct transverse separation, but rather a double oblique one, the upper fragment being obtusely pointed in front, and seeming as if it might have acted as a wedge in bursting apart the condyloid portion of the bone; and I think that this may sometimes be accepted as the true explanation of the mechanism of the lesion. Or, possibly, first one condyle and then the other may have been detached, the end of the shaft being thus, as it were, denuded; such it seems to me was the rationale of Bichat's case, quoted by Malgaigne, in which a man broke the condyles by lighting on his feet.

It will readily be seen that whether the force producing the fracture be direct or indirect, it is scarcely possible for it to act alike on both sides of the bone. Hence, as in some of the instances above cited, one or the other condyle must suffer more severely; and hence there must result a change in the position of the limb, so that an angle will be presented between the shaft of the femur above, and the leg below. Sometimes this angle will be open outwardly, sometimes at the inner side of the limb; and, slight as it may be, it will be so far indicative of the character of the lesion.

In two cases recorded by Callender,³ the patella had sunk into the space between the fractured condyles, and was so wedged there that its extrication was impossible; the patients recovered slowly, and in each case the knee was rendered permanently stiff.

The *symptoms* are pain, loss of power, deformity, often rendered very ob-

¹ Catalogue, p. 33, No. 1138¹⁰.

² Catalogue, p. 197, No. 1118.

³ St. Bartholomew's Hospital Reports, vol. vi. 1870.

scure by the swelling from effusion into the periarticular bursæ as well as into the joint itself, lateral mobility just above the joint, and crepitus.

When the case is seen very early, the *diagnosis* may present no great difficulty; but from the extreme rapidity with which swelling comes on, and the complexity of the parts involved, the surgeon is rarely able to pronounce upon the nature of the injury without reserve.

The gravity of these cases may be at once perceived. The knee-joint is of necessity involved, and must become the seat of inflammation, so that there is a great risk of ankylosis if the immediate dangers to life are surmounted. Hence a carefully guarded *prognosis* only should be given.

The *treatment* must be directed in the first place to the rectification of any obvious distortion, and then to subduing inflammatory action. During the few hours succeeding the accident, indeed, there may be a very marked collapse, and this must be met as in any other case, bearing in mind the probability of the occurrence of severe reaction in a succeeding stage.

Complete immobilization of the joint, with moderate extension and counter-extension, will I think commend themselves to the judgment of every one as the cardinal principles of the local treatment in these cases. As to the exact means to be employed, there may be room for the exercise of choice. My own preference would be for a well-fitted back-splint, and suspension in either Smith's or Hodgen's wire-frame; but I cannot speak from experience, having never treated a case of this kind except complicated with other injuries which proved speedily fatal. Theoretically, I should think that the comfort of the patient, as well as the retention of the fragments, would be promoted by a slightly flexed posture of the knee, while in the event of ankylosis this would insure a better gait than could be obtained with the limb entirely straight. Should suppuration unfortunately occur, it would be necessary to decide between evacuating the pus and washing out the joint with carbolized water, and amputation; or in young subjects the propriety of excision might be considered.

FRACTURE OF ONE CONDYLE, although more rare than that of both, has been repeatedly observed. All the cases have been in males, and the result of direct violence.

Malgaigne says that this lesion "consists in a nearly vertical division of the bone, striking the articular face near one or the other of the condyles, and directed from before backward, which goes up along the bone, deviating inward or outward, according to the condyle affected, and terminating two, three, or even four inches above the joint; the detached fragment forming a sort of pyramid, with the condyle for its base."

The *external* condyle was broken off in two cases recorded by Sir A. Cooper;¹ in both, however, the shaft of the bone was also fractured across. In another instance, reported by Crosby,² the separation of the condyle was due to a twist of the leg, and the fragment was removed by incision some months afterward. Here there may be, perhaps, a question as to the correctness of regarding the force as direct, but I am inclined to think that it was so. Hamilton mentions the case of a man aged forty, seen by him three months after the receipt of the injury; the fragment was then distinctly movable, and he was in doubt whether the fracture had involved the joint. Such a lesion would be analogous to fracture of the epicondyle of the humerus. Kirkbride³ saw the external condyle separated by the kick of a horse.

¹ Dislocations and Fractures of the Joints, pp. 241, 242.

² New Hampshire Journal of Medicine, 1857.

³ Am. Journal of the Med. Sciences, May, 1835.

Brookes¹ has published an account of a boy, aged eleven and a half years, "who had his leg entangled in a wheel, and sustained a compound fracture of the femur, extending obliquely downward through the external condyle, which was movable with the lower portion, projecting through a wound in the popliteal space. The leg was twisted inward, much hemorrhage had taken place, and the patient was in a state of collapse. On further examination, the capsular ligament was found to be lacerated, and synovia escaped—the wound in the popliteal space being as large as a five-shilling piece. There was also a simple fracture of the lower third of the same thigh-bone. Amputation having been refused, the limb was put up in the straight position, with a splint extending from the hip to the ankle on the outer side, and a concave one on the inner side of the thigh. Complete union had occurred by the end of the sixth week." At the time of the report the knee could be bent to a right angle, and the entire use of the limb had been recovered; there was no shortening perceptible.

Three other cases are cited by Malgaigne:² one seen by himself, another published by Gerdy, and a third, the specimen from which, without history, is found in the Musée Dupuytren.

The *inner* condyle has been observed to be fractured in the following instances: Wells³ saw a thick scale of bone detached from the inner part of the condyle, the tibia being at the same time luxated outward and backward; the patient could only state that he had fallen. Malgaigne quotes from Boyer⁴ a case the account of which is too meagre to be of much interest. The internal condyle was separated, the line of fracture running only a short distance upward; there was no displacement, but manifest mobility of the fragment. Consolidation took place without difficulty, and without apparent deformity. The patient could not walk for three months, and two months afterwards he still limped. Two other cases are cited in the same article,⁵ one seen by Malgaigne himself, and the other by Lisfranc. Curtis⁶ has published an account of a case seen by him, in which, from the statement made by the surgeon first called, the fragment was displaced backward, the outer side of the limb appearing normal; the joint could not be flexed by reason of the pain caused by bending it. Reduction was easily accomplished, and a good recovery ensued, the joint, however, remaining enlarged. Hamilton quotes a case reported to him by Dr. Riggs, in which, by the kick of a horse, "the internal condyle of the right femur was broken off, carrying away more than half the articulating surface of the joint; the tibia and fibula were at the same time dislocated inward and upward, carrying with them the broken condyle and the patella. The displacement upward was about two inches, and the sharp point of the inner fragment had nearly penetrated the skin. There was no external wound." Great difficulty was experienced in the reduction, but the case ultimately did well.

Two instances are cited by Morris,⁷ as follows: "M. Dubue has reported the case of a man aged sixty, who fell while ascending a ladder, and broke off very obliquely the whole of the internal condyle of the femur, and the superior external angle of the patella. Prof. Verneuil had a case in which a large cube of bone, consisting of the inner condyle, was broken off by the falling of a quantity of earth upon a man aged twenty-eight."

¹ London Med. Gazette, March 10, 1848.

² Revue Méd.-Chirurgicale, April, 1847.

³ Am. Journal of the Med. Sciences, May, 1832.

⁴ Traité des Maladies Chirurgicales, tome iii. Paris, 1845. This case does not appear in the earlier editions of Boyer's Treatise.

⁵ Revue Méd.-Chirurgicale, April, 1847.

⁶ Am. Journal of the Medical Sciences, Oct. 1866.

⁷ Holmes's System of Surgery, 3d ed., vol. i. p. 1023.

The *symptoms* of these cases would seem, as far as they have been recorded, to resemble in many respects those of fractures of both condyles; there is the same pain, loss of power, swelling, and crepitus, and in some cases, especially where the bone has been broken higher up also, there would seem to be like deformity. But if one condyle alone is separated, and the case is seen before the parts have been masked by swelling, it may be possible to grasp the fragment by itself, and to move it upon the rest of the bone, so as to gain some idea in regard to it.

The *diagnosis*, however, is extremely difficult in injuries of this portion of the femur; and for my own part, I should be unwilling to make a positive assertion as to any case in which the examination was made after swelling had taken place, unless either the detached fragment was thrown off, or an opportunity for dissection had occurred. I may say that I have seen several cases in which there was reason to believe that one or other condyle had been separated, but it was impossible to arrive at anything approaching to certainty. Theoretically, it is easy to point out what it seems ought to be the signs of one or other lesion; but in practice the matter is far more perplexing.

The *course* of these cases varies very much; sometimes excellent results have been obtained, but in other cases, either from the previous bad habits of the patients, or from the severity of other injuries, the loss of the limb, or even of life, has ensued. When recovery has taken place, the use of the limb has generally been in very great measure restored, and sometimes the cure may be said to have been perfect.

As to the *treatment*, no precise directions can be given, but the general course to be followed is the same as that advised for fractures involving both condyles.

FRACTURES OF THE PATELLA.

According to most observers who have furnished statistics, the patella is affected in something less than 2 per cent. of all the cases of fracture. Gurlt,¹ in the tables before quoted, cites from the record of the Klinik and Polyklinik at Halle, given by Blasius, the statement that out of 778 cases there were 20, or over $2\frac{1}{2}$ per cent., of the patella. On the other hand, at the Allerheiligen Hospital at Breslau, Middeldorpf reported but 3 fractures of the patella out of 325 cases, being less than 1 per cent.

By far the larger number of the subjects of fractured patella are adult males. Agnew² says that, in the Pennsylvania Hospital, out of 106 cases 96 were in men and only 10 in women; only one case was seen under twenty years of age, the largest number, 36, occurring between twenty and thirty. Fractures of the patella do not appear at all in the seven years' tables of the Children's Hospital in Philadelphia, already several times cited. Malgaigne's figures are not quite as striking as the above; out of 45 cases, 37 were in men to 8 in women. Of 20 cases observed by himself, only 4 were in women. But 1 of the 45 was in a person under seventeen years of age; one of his own cases, however, was that of a boy of eleven. He calls attention to the fact that in women, from the seventeenth year to the fifty-fifth, there were but 3 fractures of the patella; there were 5 beyond this period.

Rare as this injury is in children, it has been observed in them. Hamilton mentions the case of a boy of five, in whom, by a direct blow, a small piece of the margin of the bone was broken off. Dr. Samuel Ashhurst has reported to the Academy of Surgery, in Philadelphia, the case of a child four years old,

¹ Op. cit., Bd. i. S. 6 und 7.

² Op. cit., vol. i. p. 971.

who, by a fall, striking the knee against a glass "marble," sustained a fracture of the patella downward and inward.

The patella may be broken either by direct force or by muscular action, or by both these causes combined. The mechanism by which the bone is made to yield in the first case, is plain enough, as its spongy and easily crushed texture would ill fit it to resist a sudden blow—such, for example, as the kick of a horse. Muscular action does not produce the effect by tearing the bone apart, but by the pull exerted upon the upper portion of the bone, while its lower part is fixed by the ligamentum patellæ, and the resulting leverage over the lower end of the femur. According to this theory, which has received the sanction of most of the leading authorities, this fracture is due, like so many others, to "cross-breaking strain." Malgaigne suggests that in some of these cases the bone has been weakened by previous injury, and that in some there have been pains, or other indications of pathological change; but there have certainly been many instances in which nothing of the kind has been known to have occurred. Perhaps it is too obvious to need argument, that in many cases the muscles are in a state of tension when direct violence is applied to the bone, and that this condition aids materially in overcoming the resistance of its structure.

Desault¹ relates the case of a patient who was cut for stone, and who, in a consequent convulsion, broke both patellæ at once. Marcy² reports that a woman, aged thirty-eight, in an effort to save herself from falling, met with the same misfortune. Sir A. Cooper³ mentions another case, and Johnston⁴ another. Callender⁵ has recorded one, to be again referred to, and one was seen by Beauvais.⁶ Callender has recorded⁷ two cases in which a different mechanism was thought to have obtained:—

"I. M., aged 45, laborer, fell 20 feet, from a ladder, on his knees. There was great effusion into the right knee-joint, with fracture extending through the condyles of the femur, and comminuted fracture of the patella, without much displacement of its pieces. The injury was treated on a double-inclined plane, and the patient was discharged with a useful knee-joint. We had no doubt but that this patella was broken after fracture of the femur, by displaced fragments being driven against the articular surface of the bone. In the museum of St. George's Hospital is a transverse fracture of the patella, without laceration of the fibrous covering of the bone, produced by violence acting from within, in a case of compound fracture of the lower end of the femur, one of the fragments of the femur being driven against the deep surface of the sesamoid bone."

The line of fracture may be almost exactly transverse, or it may be more or less oblique, and in a few instances it has been seen to be longitudinal. One specimen, without history, in the Musée Dupuytren, has been accepted as an example of incomplete fracture, involving only the articular cartilage and a small portion of the underlying bony structure, and not extending to the lateral edges of the bone.⁸ It does not seem to me to be unquestionably of the character claimed for it. Sometimes the bone gives way at more than one point. Bryant mentions a specimen, in Guy's Hospital Museum, in which there were four fragments, united by ligamentous bands. There is one in the museum of the Pennsylvania Hospital,⁹ described as follows: "The bone has been fractured into five fragments, which are all bound together by a thin,

¹ Treatise on Fractures, Luxations, etc. Edited by Bichat. Caldwell's translation, p. 299. Philadelphia, 1817.

² Boston Med. and Surg. Journal, October 8, 1874.

³ Op. cit., p. 230.

⁴ St. Bartholomew's Hospital Reports, 1870.

⁵ Lancet, November 8, 1873.

⁶ Medical Times and Gazette, Oct. 9, 1880; from L'Union Médicale.

⁷ St. Bartholomew's Hospital Reports, 1870.

⁸ Holmes's System of Surgery, 3d ed., vol. i. p. 1028.

⁹ Catalogue, p. 35; No. 1146.

broad layer of fibrous tissue. The distance between the upper and lower fragments is fully $3\frac{1}{2}$ inches, the three other fragments occupying intermediate positions. The surfaces of the fragments have been a good deal rounded off, but are still quite irregular." The patient in this case was known to have twice fractured the bone. Gross¹ figures a specimen in the museum of Prof. Joseph Pancoast, in which there are three fragments, with intermediate bands. No history of double fracture or of re-fracture is given.

Lonsdale speaks of having seen a man who "fell and struck his knee against the edge of a curb-stone; the fracture took a direction so as to leave the lower portion projecting angularly upwards, fitting into the upper." In comminuted fractures, there is not unfrequently a line of separation more or less transverse, and the lower fragment is again divided by one or two splits running downward from this main fracture.

An anatomical point of importance is well set forth by Tillaux² in regard to the connections of the patella. He describes the "lateral ligaments" of the bone as continuous with and arising from the *ligamentum patellæ*. Strongly attached to the lateral borders of the patella, where they (the ligaments) are very thick, they pass backward, surround the condyles, and are inserted into the fibro-cartilaginous capsule with which the *gastrocnemii* are connected. These lateral ligaments, he says, "constitute a powerful protection for the front of the knee, and play an important part in fractures of the patella, according as they are more or less torn. When they are but slightly torn, or not at all, as happens in fractures by direct violence, which, indeed, are the rarest, they hold the fragments together; if, on the other hand, they are much lacerated, the unopposed quadriceps muscle drags the upper fragment upward, until it may be separated from the lower by several fingers' breadths. This point must be taken into the account in estimating the value of different methods of treating these fractures, since in the one case the fragments remain in contact, of themselves, while in the other it is difficult to control them even with the best contrived means."

When transverse fracture of the patella occurs, the lower fragment remains in place, being attached to the tibia by the very strong and unyielding *ligamentum patellæ*. But there are two agencies by which the upper fragment may be separated from it, so that there exists a perceptible gap between them. One, already alluded to, is the contraction of the quadriceps muscle; the other is effusion of serum, and sometimes of blood also, into the knee-joint. Both of these, it must be obvious, will be limited in their action by the lateral ligaments of which I have just quoted Tillaux's description; but the muscle may be powerful enough to tear the ligaments, and thus to produce the displacement. Indeed, it may well be doubted whether it is not in this way that laceration of the ligaments always occurs, since they can seldom be directly ruptured by the fracturing force except just at the edges of the bone; yet having given way here, their further tearing can scarcely require any very great force. Once torn, however, the greatest obstacle both to muscular action and to effusion into the joint is removed; and separation of the fragments will very soon take place.

It must not be forgotten that the strength of these ligaments varies in different individuals; and it is doubtless for this reason, as well as because of the varying degree of the violence sustained, that in some cases there is at once a wide gap between the portions of the bone, while in others the fragments remain almost in contact until inflammatory effusion occurs in the joint.

Mr. Jonathan Hutchinson³ maintains that the quadriceps extensor muscle

¹ System of Surgery, vol. i. p. 1000.

² Anatomie Topographique, p. 1103.

³ Med.-Chir. Transactions, vol. liii. 1869.

is singularly inactive in cases of transverse fracture of the patella, and that the separation of the fragments is due largely to fluid pressure from within the joint. He says that the muscle occasionally undergoes marked and permanent atrophy.

Vertical or longitudinal fractures of the patella are always due to direct violence, and differ from the transverse in the much less separation of the fragments. Dupuytren¹ gives four cases of this kind, in one of which it is stated that the bone was divided into two nearly equal portions. He speaks of having treated several other cases at the Hôtel Dieu, and thinks them less rare than they have been generally supposed to be. Lonsdale, Cooper, and others, have met with them in the dead subject. The literature of the subject is very scanty, and I know of no recent reports of such cases.

Rupture of the prepatellar bursa is very apt to occur, whether the bone gives way to direct violence or to muscular action; in the former case it is by bursting, in the latter by tearing of its posterior wall. It is not of any importance as compared with the lesion of the bone.

The *symptoms* of this fracture are generally well marked; the patient falls—and sometimes it is difficult to say whether the fall is the cause or the result of the injury to the bone; there is pain, aggravated by the strain upon the fibrous structures surrounding the bone which must attend any attempt at movement; there are swelling and deformity, and, unless the upper fragment has been dragged away entirely from the lower, crepitus is very easily elicited.

These symptoms are by no means always equally clear. Trésoret² has published an account of a robust man of forty-five, who struck his left knee in a fall. He kept at work for three weeks, and then, examining his knee on account of its being swollen, he thought that the bone was broken. Two months after the accident, he applied for advice, when a transverse fracture between the middle and lower thirds of the bone was easily detected. A cyst (?) had formed at this point; iodine was injected, and a month afterward the patient was considered as cured. Morris³ mentions the case of a young woman who struck her knee forcibly against a chair: “for part of two days she got about the house and up and down stairs, moving, however, with great difficulty and much pain,” when an oblique fracture of the patella was detected.

Tillaux⁴ mentions a source of error in the diagnosis of fracture of the patella, which, he says, he has several times witnessed: “An effusion of blood in the prepatellar bursa may give rise to crepitation, and the clots may even cause a sensation exactly like that of separation of the fragments.” He is of opinion that this may have been the real state of things in some cases in which fracture has been supposed to exist, and in which it has been claimed that a perfect cure with bony union was effected. When there is doubt as to the existence of fracture, Mr. H. Morris recommends⁵ “fixing the bone between the finger and thumb of one hand, and then pressing all around the circumference of it with the index finger of the other.” Dupuytren⁶ cites a case seen by Breschet, in which it was very difficult to determine the nature of an injury, sustained by a patella which had been fractured twelve years previously; the joint had become almost entirely ankylosed, and the conclusion arrived at was that the union had given way.

The *course* of these cases is very various, but that which is most usually observed is a gradual subsidence of the inflammation in and about the joint, and the formation of a ligamentous connection between the fragments. If

¹ Diseases and Injuries of Bones, Syd. Soc. Transl., p. 225.

² Gaz. des Hôpitaux, 11 Août, 1881.

³ Holmes's System of Surgery, 3d ed., vol. i. p. 1029.

⁴ Op. cit., p. 1124.

⁵ Loc. cit.

⁶ Op. cit., p. 228.

there is no displacement, as occasionally happens by reason of the fibrous envelop and lateral ligaments remaining intact, this fibrous band may be exceedingly short, so that the fragments are very close together. But cases are upon record in which the separation, at first only slight, has been increased upon the use of the limb being resumed; and it is, I think, the rule that in every case some such increase takes place, unless the fragments have been united by bone. For bony union does sometimes occur; there are several specimens of it in the Mütter Museum of the College of Physicians of Philadelphia, and one is figured by Malgaigne; several are mentioned by Mr. H. Morris.¹ In such cases the usual rule obtains, that on the articular face of the bone there is rather a loss of substance than a deposit of callus, so that the line of fracture is marked by a shallow groove. T. C. Smith has recorded² a case of fracture of the patella by a fall on the knee, the outer condyle of the femur being also broken off. There was no separation; firm osseous union ensued in about six weeks, and no observable deformity was left from either fracture.

Sometimes, as in a specimen figured by Morris,³ it seems unquestionable that there has been a new formation of fibrous tissue, developed from a plasma, just as in some instances of like union between other bones; but this is not always the case, for there may be only an expansion of pre-existing ligamentous substance. When the fragments have been tilted, the attachment of these fibres may be somewhat changed, as in another example given by Morris.⁴ Kirkbride⁵ has reported a case in which the fragments had become united at their inner part by a round fibrous cord, the remainder of their extent being unconnected; with the knee in the straight position, they were two inches apart at the outer side and one and a half at the inner, while on flexion of the knee the distances were increased to three and three-fourths and two and a half inches. The patient had good use of the limb, and walked without any perceptible limp.

Irregular pressure by apparatus, or perhaps the unequal yielding of different portions of the ligamentous structures, may give rise to lateral tilting of the fragments, so that the gap between the latter is wider on one side than on the other. And sometimes there are irregular deposits of bone in the uniting medium, showing an effort at the establishment of bony union. Both these points are illustrated in a preparation in the museum of the Pennsylvania Hospital:⁶ "The fracture has been transverse, about the middle of the bone; the fragments are covered by a thick membrane; a broad, fibrous layer, an inch and a quarter wide, unites the two fragments, being attached to their anterior surface. There is also a strong but thin band passing between their posterior surfaces. At the outer side of the patella there are two bony nodules springing from each fractured surface; these are evidently new-formed bone, and are almost in contact with each other, though no bony union has occurred between them; they were, however, firmly bound together by ligament. The degree of separation at the outside of the joint is not more than half an inch; at the inside it amounts to fully an inch." This specimen was taken from the body of an old negro, who had sustained the fracture eleven years previously.

Hamilton⁷ makes the extraordinary statement that in the case of a young man of nineteen, with a transverse fracture caused apparently by a direct

¹ Loc. cit.

³ Loc. cit., p. 1031; fig. 175.

⁵ Amer. Journal of the Medical Sciences, May, 1835.

⁶ Catalogue, p. 35; No. 1145.

⁷ Treatise on Fractures, etc., 6th edition, p. 502.

² Am. Journal of the Med. Sciences, April, 1873.

⁴ Ibid., fig. 176.

blow, 'the ligament subsequently gave way completely on the outside, and a new patella formed in the very much elongated ligament on the inner side.'

It must be clear that in so far as the separation of the fragments is due to effusion within the joint, it must lessen as the fluid is absorbed; and this phenomenon has been strikingly described by Malgaigne, as noted by him in two of his own cases. But the contraction of the quadriceps muscle can only induce a progressive increase of the interval, and may thus act, if unopposed, for a long time.

Malgaigne says that the greatest separation within his knowledge was one observed by Sir A. Cooper, which amounted to four inches; but Cooper himself says,¹ "the bone may be drawn five inches upward, the capsular ligament and tendinous aponeurosis covering it being then greatly lacerated; and this, with one exception, is the greatest extent of separation which I have seen." And Morris² says that "in St. Thomas's Hospital Museum are two specimens in which the ligamentous union is six inches or more in length."

A curious shortening of the ligamentum patellæ sometimes occurs; and though it is not generally of great extent, yet it contributes somewhat to the ultimate amount of separation between the fragments. Perhaps this is due in some degree to pressure by apparatus, which certainly often has the effect of causing the gap to be greater at the anterior surface than at the posterior. Callender³ has noted the occasional occurrence of hypertrophy of the fragments, as well as the fact that the opposite condition has been met with, the broken portions becoming atrophied. He also mentions a specimen, in the museum of the Middlesex Hospital, in which the lower fragment has become united by bone to the tibia, so that the fibrous band between the fragments had come to represent the ligamentum patellæ.

In one or two recorded instances, the upper fragment has contracted adhesions to the femoral condyles, but without any direct influence in impairing the usefulness of the limb.

Refracture of the patella is not a very unfrequent occurrence. Sometimes, but rarely, the bond of union gives way. More frequently the bone separates at another point; and this, I think, is to be accounted for on the ground that as the use of the limb is acquired, one or other of the fragments comes to bear, as the original bone did, over the lower extremity of the femur, this portion then giving way under a "cross-breaking strain." I have myself reported⁴ a case in which, under the use of Malgaigne's hooks, I had succeeded in getting extremely close union of a transverse fracture, and the bone gave way, apparently at the same point, four months afterward, under a sudden slight strain. But instances of this kind are not common. Little⁵ has recorded a case in which, ligamentous union having occurred, a second fracture, half an inch higher up, took place nine months afterward; so that when the patient finally recovered, there were three fragments and two clearly defined fibrous bands. Parson⁶ published an account of a case in which (in December, 1874) the left patella was fractured at the junction of the middle and upper third; in October, 1880, the same bone gave way at the junction of the middle and lower thirds, and in August, 1882, it was again broken at the same point. Lloyd⁷ saw a patella broken by direct violence, which gave way again twice at intervals of twelve months. Bryant mentions a case seen by him, in which one patella had been broken twice, and the other three times.

It is not very difficult to see why fracture of one patella should occasion

¹ Dislocations and Fractures of the Joints, p. 224.

² Loc. cit., p. 1030.

³ St. Bartholomew's Hospital Reports, 1870, p. 49.

⁴ Am. Journal of the Med. Sciences, Oct. 1861.

⁵ Med. Record, March 4, 1882.

⁶ Lancet, May 19, 1883.

⁷ Birmingham Medical Review, March, 1883.

ally be followed by a like misfortune to the other. The patient will naturally spare the limb which has already suffered, and in case of a slip, or any demand for effort, will be likely to put a severe stress upon the better one, which yields as its fellow did. The interval between the fractures is sometimes a long one. I have now under treatment at the Episcopal Hospital a robust and healthy man with fracture of the right patella, in whom the bone of the left side was broken about two years ago, and is united by a short fibrous bond. He was not aware of any lameness or weakness of either limb.

When refracture occurs, the damage done is sometimes far more serious than that of the original accident. Thus King¹ met with a case in which, five months after a fracture of the patella, union having taken place with the fragments about half an inch apart, the whole knee was burst open, a wound seven inches long being produced, and the fragments separated an inch and a quarter. Suppuration ensued, but the patient made a good recovery; the amount of motion in the knee, if any, is not stated.

Charles Bell² mentions a very similar instance. "The bone had united by ligament, and this ligament had incorporated with the skin in such a manner that it lost much of its pliancy. The poor man was carrying a burden and fell backward, the knee sank under him, and the whole forepart of the joint was laid open by laceration. The case terminated in amputation of the limb." Malgaigne, after referring to this case, says: "I have seen a nearly similar instance; the rupture of the fibrous band was attended with enormous ecchymosis, gangrene ensued at about the fifth day, and death closed the scene. M. Seutin quite recently sought in vain to save a limb thus affected; after four months of suffering, amputation of the thigh became the only resource."

Thomson³ reported to the surgical section of the British Medical Association, a case of old fracture of the patella, in which suture of the fragments had been practised; a year later, the knee being stiff, the patient tripped, and burst open the whole joint. Resection was performed, with a good result. He refers to other like cases seen by Bell, Poland, and Pelletan, in all of which amputation was deemed necessary. A very similar instance has been placed on record by Mason,⁴ and another, but with a far more fortunate issue, by Roberts.⁵

Necrosis of a portion of the fractured bone has been observed in a very few instances. One of these is given by Erichsen,⁶ as follows: "The patient, a middle-aged man, had met with an ordinary transverse fracture of the patella, which united by ligament two years after the accident; and without any fresh injury he came to the hospital, with necrosis of the outer half of the upper fragment, which was completely detached, and lying in a cavity bounded and shut off from the joint by plastic matter. I cut down upon and removed the necrosed fragment, which appeared to constitute about one-quarter of the patella. No cause could be assigned for the necrosis, except defective vascular supply to this part of the bone." Another instance is briefly referred to by Lawson,⁷ "in which a portion of the patella was chipped off, necrosed, and fell into the joint, there setting up inflammation, which caused death." Hulke⁸ says that a partially detached portion of one of the fragments may die and be gradually exfoliated, as in Liston's patient, a sailor, aged twenty-four, who died seven weeks after the injury from hectic fever following extensive suppuration in and around the knee-joint.

¹ Dublin Med. Press, Dec. 8, 1847.

² A System of Operative Surgery, 2d Am. ed., vol. ii. p. 361. 1816.

³ British Med. Journal, Aug. 26, 1882.

⁴ Med. Record, March 20, 1875.

⁵ Bryant's Surgery, 3d Am. ed.

⁶ Science and Art of Surgery, Am. ed., vol. i. p. 381. 1873.

⁷ British Med. Journal, June 9, 1877.

⁸ Holmes's System of Surgery, 3d ed., vol. i. p. 1028.

A fact of much importance, as will be seen when the subject of treatment comes under discussion, is that the usefulness of the limb after recovery from fracture of the patella is not necessarily in proportion to the closeness of apposition of the fragments. I have seen a number of persons who had had this injury, and in whom very great separation remained, who yet were able to walk, to go up and down stairs, and even to mount, as for instance into a chair, as well apparently as ever. One very large and portly man, well known for years in Philadelphia, had had fracture of both patellæ at different times, with very lengthy ligamentous union, and yet he walked about freely, and showed no peculiarity of gait beyond what might have been perfectly natural to him.

Such, however, is not always the case. Callender¹ says: I note in April, 1866, the case of a poor fellow who had fractured either patella some years previously, and who was admitted for some other trouble. He had lost all power of recovering himself when the body was bent back from the knees, and thus he constantly fell whilst moving about. In his case the interval between the two fragments of bone on each side was less than two inches and a half, but then both knees were damaged." My belief is that much depends upon the confidence felt by the patient; and it is very probable that in a case of simultaneous fracture of both bones, the loss of power would be apt to be greater and more persistent than if the injury should be sustained first in one limb, and at some later period in the other.

When fracture of one patella has taken place, and even when, as in an instance recorded by Hamilton,² the fragments are separated to a distance of four and a half inches, and no bond of union can be detected, the rule is that in a greater or less length of time, with judicious management, the strength and usefulness of the limb are in a very complete measure regained. Hence it seems to me that the *prognosis* of these cases may be favorable, so far as the ultimate result is concerned; but the patient should not be led to think that his recovery will be speedy, not only lest he should be disappointed, but also lest he should by imprudence sustain further damage.

As to the *treatment*, a great deal of ingenuity has been expended in the endeavor to devise means of holding the fragments in apposition, or as nearly so as possible; and a vast number of appliances for this purpose, many of them very similar in principle, and varying only in trifling details, have been described, each with its inventor's name. I shall not attempt to give a complete list of these, but propose to state the objects to be aimed at, and the chief methods by which they may be attained; not omitting any practical suggestions, but not being careful to mention all the curious and complicated mechanisms which have been from time to time recommended, without acquiring more than a transient and local reputation.

Surgeons have differed as to the best position in which to place the limb, some advocating the flexion of the hip-joint, others deeming it of little importance. Callender³ says: "I hope the old fashioned plan of raising the limb on an inclined plane for the treatment of fracture of the patella is quite obsolete. Fractures of this sesamoid bone are now treated in St. Bartholomew's by rest simply, the limb lying in the horizontal position." On the other hand, Mr. Croly, of Dublin, is said⁴ to be "content to obtain good fibrous union by simply elevating the limb, so that a line drawn from the toe will pass on a level with the patient's nose, the chest and shoulders being raised by a bed-rest, and subduing all inflammation by ice and evaporating lotions."

¹ Loc. cit., p. 49.

³ Loc. cit., p. 48.

² Op. cit., 6th ed., p. 527. 1880.

⁴ Lancet (editorial), March 31, 1883.

While it is very probable that the importance of flexing the limb strongly upon the body may have been overstated by some writers, it seems to me that surgeons generally would be unwilling to forego the advantage gained by complete relaxation of the muscles on the front of the thigh. But in order to secure this, it is not necessary to place the limb at an angle of less than about 130° with the axis of the body. It is, however, essential that the knee should be kept in the extended position, and this becomes very irksome from stretching of the posterior muscles, if the hip-joint is strongly flexed. So generally has the propriety of this posture of the knee been recognized, that almost all surgeons have included a back-splint in their appliances for dealing with fractures of the patella. By some the ordinary single-inclined plane is used, so arranged that the degree of elevation of the foot may be altered at the will of the attendant. Others have employed a trough of tin, gutta percha, binders' board, or some like material; while many prefer a board, either sloped off above and below, or padded, so as to fill up the hollow of the ham. If such a board is used, it should be of suitable width for each portion of the limb, very slightly hollowed out along the middle, and at its ends the edges should be carefully bevelled off so as to make no pressure upon the skin.

Plaster-of-Paris bandages have been used by some surgeons, and the starched bandage is highly recommended by Erichsen; but neither of these can, in my opinion, be safely employed, except in the later period, when the patient is beginning to weary of confinement, and union has so far progressed as to be in a measure assured. Hamilton quotes several cases in which the injudicious use of plaster of Paris, or of a silicate bandage, seemed to be the clearly assignable cause of very imperfect results, and one has been recorded¹ in which gangrene ensued, and amputation had to be performed.

I will merely mention that some surgeons on the Continent of Europe have resorted to what must, I think, be regarded as an unjustifiable practice—the aspiration of the knee-joint for the removal of the effused liquid, by which it is apt to be distended for a few days after the accident. Such interference is not only theoretically attended with risk, but it has been actually proved so. I do not refer to the rare cases in which a formidable arthritis has already been set up, and in which there is an existing danger from the products of inflammation within the joint, although as to even these there are conservative surgeons who would hesitate to adopt such measures; but to those cases in which the effusion is a mere temporary inconvenience, and in which nature will do the work of relief as surely and much more safely, if not as promptly, as any surgical instrument.

For a few days, then, until the swelling of the joint has subsided, the best course is to place the limb at rest on a back-splint, and to employ suitable means for allaying the local irritation. Evaporating lotions, lead-water and laudanum, or hot water-dressing, may be made use of, the choice being determined according to the age and strength of the patient, the season of the year, and perhaps other circumstances.

Upon the disappearance of the effusion into the joint, means must be adopted for approximating the fragments. Should the tendency to separation be very great, an attempt should be made to control it even from the outset; for although the bringing of the fragments together may be impossible, and even inadvisable for fear of injury to the joint, yet the subsequent coaptation may be rendered easier. The best way of doing this is by means of a compress of folded lint, having around it an envelope of adhesive plaster, the adhesive surface outside; this being placed on the skin just above the

¹ Am. Journal of the Med. Sciences, Feb. 1840; from the Gaz. Médicale, 1839, No. 28.

upper fragment, and the middle of a strip of bandage laid over it, the ends of the bandage may be gently drawn upon, and secured to pegs or nails at either side of the splint, at such points that the tension shall be exactly in the direction desired.

The aim of most of the inventors of appliances for the treatment of these fractures has been to act on both fragments, forcing them together. But, in fact, the lower one is not displaced, unless by the shortening of the ligamentum patellæ, before spoken of; and it is very doubtful whether this is not actually promoted by pressure brought to bear upon it in some methods.

Various devices for circular pressure were used at a very early date; Malgaigne speaks of splints perforated in the centre, and kept in place by a bandage (the patella being received into the opening, by the edges of which the fragments were held together), as known to Albucasis, Guy de Chauliac, and others. This plan, he says, was still employed at the Hôtel Dieu in the latter part of the last century.

Another development of the same idea was the ring or cap, which has been revived in modern times by Knight,¹ Gibson,² Eve,³ Blackman,⁴ and perhaps others. Its simplicity is its only recommendation, and although it may answer well where there is little or no gap between the fragments, and where mere support is required, it is not likely to take the place of appliances which admit of greater adaptation to the circumstances of each case. A positive objection may be made to it on the ground of its interfering with the nutrition of the bone. Gross⁵ quotes Manning as having "observed by dissection that the vascular arch of the upper fragment is situated at the precise spot where the greatest amount of pressure is usually made by the retentive apparatus; and that the lower fragment experiences a similar fate when, as not unfrequently happens, the internal superior and inferior arteries arise from a common trunk." By Thomas,⁶ also, the importance of non-interference with the circulation of the patella is urged.

By a great many surgeons, the use of pressure by bands, with or without compresses, and arranged in various ways, has been relied upon. Thus Dorsey used a back-splint, with tapes fastened to it, which were brought up above and below the broken bone, so that they should draw the fragments into place; the lower one passing above, and the upper one below, crossing one another at each side. A somewhat similar arrangement, but with pegs for tightening the bands, is recommended by Agnew.⁷ Perhaps it need hardly be pointed out that by changing the points of attachment of the tapes or bands, the traction may be brought more or less parallel with the long axis of the limb; and that the further apart they are, the more directly will the fragments be drawn together. Hamilton uses a moulded trough, and figure-of-8 turns of a roller. Sir A. Cooper laid tapes along the limb on either side of the fractured patella, and then applied a roller, leaving the patella uncovered. By drawing up the ends of the tapes, and tying the corresponding ones together, the turns of the roller above and below the knee were approximated, and with them the fragments. The obvious objection to this plan is the circular constriction which it of necessity involves. Gerdy's method was somewhat similar to this. A much better device, but still subject to the same inconvenience, was afterward used by Cooper;⁸ it was a leathern band buckled round the thigh just above

¹ Am. Journal of the Med. Sciences, July, 1860.

² St. Louis Med. and Surg. Journal, Oct. 1866. This author claims to have obtained bony union by means of the ring.

³ Nashville Journal of Medicine and Surgery, Feb. 1867.

⁴ Western Journal of Medicine, May, 1868.

⁵ Op. cit., vol. i. p. 999.

⁶ Med. Press. and Circular, Oct. 11, 1882.

⁷ Op. cit., vol. i. p. 974.

⁸ Op. cit., p. 229.

the patella, and drawn down by another strap passing down from it, around the sole of the foot, and then up along the other side of the leg. An apparatus, very similar in principle, has lately been proposed by Levis, of Philadelphia.¹

A plan which has in my hands proved very satisfactory, is known as Sanborn's. Its peculiarity consists in the use of a strip of adhesive plaster along the upper surface of the limb, leaving a free loop just over the patella. Compresses having been applied, and the ends of the strip secured by transverse strips and a roller, the loop is twisted up by means of a bit of stick passed through it, until the compresses are so drawn together as to bring the fractured surfaces as nearly as possible into contact. The stick is then secured by tying its ends with a strip of bandage passed round under the back-splint. Of course the pressure can be increased at any time by twisting the loop up tighter, and can be lessened by untwisting it.

A number of appliances have been proposed, and a few of them have been extensively used, with semicircular or crescentic plates of metal, arranged to press against the upper and lower edges of the fragments, and to push them together. Of these, Lonsdale's² was the first; his plates were carried on arms attached to the back-splint, and by means of screws and nuts could be adjusted so as to produce the desired effect. I need hardly enumerate the other forms of apparatus based upon this idea, as they can be found described in readily accessible works, and have mostly had but an extremely limited use. Some of them are complicated, and others inefficient.

Perhaps I may be permitted here to digress for a moment, and to say that this subject of the treatment of fractures of the patella affords a striking illustration of the fact that in surgical appliances and methods what is wanted is not power, not mere brute force, but exact adaptation. Much ingenuity has been expended upon the invention of apparatus to overcome resistance which it is far better to evade than to oppose, to coax than to compel.

An apparatus employed at the Middlesex Hospital,³ in London, seems to me to possess very great advantages, and I will quote the description of it in full:—

“A broad piece of moleskin plaster, cut out at one border, somewhat horseshoe-shaped, but with the ends of the curve prolonged, is fixed to the thigh, so that the curved edge is level with the normal position of the patella, and is retained by means of a few turns of roller. Next the limb is fixed upon a well-padded McIntyre or simple wooden back-splint having a foot-piece. Then the lower fragment of the patella is fixed by means of a pad of lint and broad strip of adhesive plaster applied figure-of-8 fashion around limb and splint; and the bandage which confines the foot and leg to the splint is continued upward as far as this pad, which it assists in fixing. To the prolonged ends of the moleskin plaster are sewn pieces of bandage (pieces of moleskin plaster of different sizes cut to the right shape, and having the pieces of bandage fastened on, are always kept ready) which are attached in turn to India-rubber accumulators, one on each side of the leg; each of the accumulators at its lower end is fastened to a piece of bandage, and these are tied together below the foot-board of the splint. With a pad of lint at the upper border of the superior fragment of the patella beneath the free edge of the moleskin, the requisite amount of tension is obtained by tightening the tied pieces of bandage.”

I am at present using this plan in two cases in my wards at the Episcopal Hospital, and find it satisfactory.

A very elegant, but very complicated arrangement for the use of weights and pulleys in coaptating the fragments of the broken patella, the invention

¹ Agnew, *op. cit.*, vol. i. 980.

² *Treatise on Fractures*, p. 427.

³ Holmes's *System of Surgery*, 3d ed., vol. i. p. 1032.

of which is ascribed to Dr. Burge, of Brooklyn, is figured by Agnew. Callender,¹ Hornibrook,² and Grant³ have suggested simpler devices for merely drawing down the upper fragment by means of a weight and pulley. I think that instruments of this kind would scarcely be available in practice, unless with extremely tractable patients.

Malgaigne's hooks, intended to act directly upon the bone itself, and to keep the fragments in exact apposition, have been by some surgeons regarded with great favor, while by others they have been strongly condemned. The instrument, as used by its inventor and by others, myself among the number, consisted of a pair of steel plates, each carrying a pair of strong recurved hooks, and having on its upper face a block perforated with a female screw; the hooks having been inserted through the skin so as to catch, one the upper edge of the upper fragment, the other the lower border of the lower one, were brought toward one another by turning a male screw through the blocks, and the fractured surfaces were thus forced together. Within a few years, Morton and Levis⁴ have employed these hooks, detaching them so as to make them into two independent pairs, or into a set of four movable hooks. The question with regard to them, however, is not of their efficiency, which is obvious, the modifications suggested being merely for convenience in application; it is whether their use is or is not attended with danger. On this point Agnew⁵ says:—

“Once have I seen death follow the use of this infernal machine, from an erysipelatous inflammation extending into the joint, and giving rise to abscesses, both within and without the articulation. No advantage whatever results from the close contact of the fragments accomplished by the instrument; it is rather a disadvantage, as the tendency to refracture is increased by the very closeness of the union, the intermediate bond not being as strong as the ordinary fibrous tissue which fills the gap when the pieces of the bone are a short distance apart. Three times have I seen the union broken a few weeks after the patients treated by this method had been discharged from the hospital.”

Hamilton⁶ quotes from Volkmann: “That Malgaigne's hooks have caused ulceration of the joint and death of the patient in a number of cases, is only too true; I, myself, know of two which occurred in the practice of friends, and which were never published, and another sad experience was met with in my own clinic a number of years since.” On the other hand, De Morgan,⁷ speaking from his experience with the hooks in the Middlesex Hospital, says “there is no method of treatment which, with so little trouble to the surgeon or irksomeness to the patient, will produce such satisfactory results.”

Hamilton, while he says that “several cases have been reported of dangerous or disastrous inflammation induced by the hooks,” thinks that “in cases in which the original separation exceeds one or one and a half inches, and especially in cases of a refracture or rupture of the fibrous band, accompanied with great separation,” the plan is entitled to a further trial.

In the case recorded by me,⁸ in which the hooks were used, they caused no inflammation of any moment, and by experiment on the dead subject I afterwards satisfied myself that there could be no risk, with ordinary care and skill, of wounding the knee-joint in their application. With the exception of the cases referred to by Agnew and Volkmann, and one reported by

¹ Practitioner, March, 1875.

² Edinburgh Med. Journal, Oct. 1876.

³ Medical News, Jan. 7, 1882. See, also, Surgery in the Pennsylvania Hospital, p. 274.

⁴ Op. cit., vol. i. p. 980.

⁵ Clinical Lecture, Med. News and Abstract, April, 1881.

⁶ British Med. Journal, May 24, 1842.

⁷ American Journal of the Medical Sciences, April and October, 1861.

⁸ Canada Lancet, Jan. 1876.

Mr. Royes Bell,¹ I do not know of any distinct statement of damage done by this plan of treatment; and if the obtaining of very close apposition of the fragments were the only condition of restoring the usefulness of the limb, I should regard the employment of the hooks as not only justifiable, but an imperative duty. Such, however, is not the case; very many patients, as has been before stated, are able to walk, climb, and run, with the fragments connected by fibrous bands of considerable length; and it seems to me that the question is, therefore, one which may be left to the individual judgment of each surgeon. Those who use the instrument are not to be adjudged foolhardy, and those who abstain from employing it are not necessarily timid or over-cautious.

Trélat is said by Stimson² to have applied the hooks through the medium of plates of gutta-percha, moulded to the anterior aspect of the limb above and below the knee; thus avoiding the wounding of the skin, and, of course, placing the joint beyond all risk of harm. Similar plans have been advocated by Spence³ and by Gant.⁴ But whether the instrument is not deprived of its efficiency by this change, may be seriously questioned.

Of late years, even bolder procedures have been advocated and practised, with a view to securing apposition of the fragments in transverse fractures of the patella. Operations similar to those mentioned in the early part of this article⁵ as performed in cases of non-union of other bones, the exposure and wiring together of the broken portions, have been resorted to, and in many cases with success, notwithstanding the unavoidable risks from the neighborhood of so large a joint as that of the knee. The idea is not altogether a new one. Hamilton⁶ says: "Severinus, an Italian, proposed to make an incision into the joint, exposing the fragments, and then to freshen the broken surfaces and bring them together." This was nearly three hundred years ago, when surgeons did not pretend to have any specific for preventing inflammation after wounds of large joints, such as Mr. Lister thinks we possess to-day." Malgaigne also refers to this proposal, but only to condemn it. According to Byrd,⁷ Dr. George McClellan, of Philadelphia, adopted such a course many years ago, in one instance, and as an experiment, which is said to have proved successful; but no account of this case was ever published, and it certainly seems as if more would have been known of so bold a procedure, and as if the surgeon would have had imitators, if the result had been favorable. It was also among the achievements of Prof. Cooper,⁸ of San Francisco.

As has been before remarked, the gravity of fractures of the patella depends in no small degree upon the involvement of the knee-joint; and the same may be said of these operations. By the advocates of Listerism, it is claimed that "antiseptic precautions" diminish the risk of opening the joint-cavity.⁹ Rose¹⁰ reported to the Medical Society of London, two cases of fracture of the patella

¹ *Lancet*, April 29, 1882.

² *Op. cit.*, p. 561.

³ *Practitioner*, March, 1875; *Med. Times and Gazette*, Aug. 21, 1875.

⁴ *Lancet*, April 29, 1882.

⁵ See pp. 62 *et seq.*

⁶ Clinical Lecture in the *Med. News and Abstract*, April, 1881.

⁷ *New York Medical Journal*, May, 1876.

⁸ As claimed in a letter from him, quoted in the *Medical Times and Gazette*, Nov. 2, 1861. The original report I have been unable to find.

⁹ Lister himself is reported (*Lancet*, Nov. 22, 1879) to have said that "the risk a patient incurs in having his knee-joint opened antiseptically is not greater or so great as that attending the removal of an ordinary fatty tumor without antiseptic treatment." I have no hesitation in saying that such a claim is unsupported by the experience of the profession at large. Perhaps I may say here that there is often a confusion between safety and impunity. The fact that an operation has been done with success, does not by any means show that it did not involve great risk. Persons have fallen from great heights, sustaining only slight injuries; but they certainly were in most imminent danger.

¹⁰ *Lancet*, Jan. 22, 1879.

in which he opened the knee-joint, drilled the fragments, and fastened them together with silver wire. The operations were done with antiseptic precautions; no bad symptoms ensued, and the final result in each case was satisfactory.

Cameron¹ gives the case of a man, aged thirty-five, in whom the broken patella had formed a wide ligamentous union, the fragments being, in extension of the knee, three inches apart, and in flexion admitting the breadth of the hand between them; he sutured them with thick silver wire, under antiseptic precautions, leaving a drainage tube in the joint. The result was satisfactory; eight months afterward the man had difficulty in flexing the knee, owing to the shortening of the parts in front.²

Other instances have been recorded, without a distinct statement as to the fact of interference with the joint. Thus Barling³ showed to the Midland Medical Society "an adult patient who by a fall had torn the ligamentous union of an old fractured patella. By a longitudinal incision over the bone, the fragments had been laid bare, refreshed, and then approximated by a single silver wire suture, which was cut off short and left. The operation had been performed some weeks before, and the fragments were in good position. In course of time, Dr. Barling hoped that solid osseous union would take place." Holmes⁴ records the history of an attempt to obtain bony union in a case in which the fragments were connected by fibrous tissue; an incision was made with antiseptic precautions, and a suture applied; the patient's life was seriously endangered by suppurative inflammation.

Other cases have been reported in various journals.⁵ One instance in which very little good seems to have been accomplished is recorded by Lloyd.⁶ The fracture was caused by direct violence; the knee gave way about twelve months afterward, and again twelve months after that. Malgaigne's hooks were then used, but without success, and incision, resection, and suture were employed, with division of the quadriceps tendon, of the tissues at either side of the bone, and of the ligamentum patellæ. The suture was allowed to remain; the fracture, however, was still ununited.

Lund⁷ has proposed a plan of treatment combining the idea of Malgaigne's hooks and that of suture of the fragments. He advocates keeping the limb extended, on a back-splint with a foot-piece, and slightly raised; a cold evaporating lotion, or ice, is applied to the knee until nearly all effusion has subsided. Then, under anæsthesia, a strong screw-pin is driven into each frag-

¹ Glasgow Medical Journal, April, 1883.

² In the Index Medicus for August, 1883, I find the following title: Henzelt, Ueber die Behandlung der subcutanen Querfracturen der Patella mit besonderer Berücksichtigung der Punction des Gelenkes und der Knochennaht. Dorpat, 1883. (On the treatment of simple transverse fractures of the patella, with reference especially to puncture of the joint and suture of the bone.) The work itself I have not seen.

³ British Med. Journal, April 14, 1883.

⁴ St. George's Hospital Reports, 1879.

⁵ Ward (British Med. Journal, June 9, 1883) records five operated on in the Leeds Infirmary, three having been cases of simple and two of compound fracture. I find also in the Index Medicus the following:—

Weinlechner, Eine durch Verschüttetwerden erzeugte Fraktur der Patella, welche das Gehen wegen weiten Abstandes der Bruchstücke und unvollständiger Streckung des Unterschenkels behinderte, kam nach sechsmonatlichem Bestande durch Resection und Naht der Bruchstücke zur Heilung mit normaler Function. (A fracture of the patella by direct violence which hindered walking by reason of the wide separation of the fragments and inability to extend the leg; after six months the normal function was restored by resection and suture of the fragments.) Aertzl. Bericht der k. k. allgem. Krankenh. zu Wien, 1882.

Sacré, Fracture ancienne de la rotule droite; avivement; suture osseuse; guérison avec ankylose. (Old fracture of the right patella; freshening of edges; suture of the bone; cure with ankylosis.) Journal de Médecine, Chirurgie et Pharmacie, Bruxelles, 1883.

Wahl, Naht einer Patella-fraktur. (Suture of a fracture of the patella.) Deutsche med. Wochenschrift, Berlin, 1883.

⁶ Birmingham Medical Review, March, 1883.

⁷ Lancet, April 29, 1882.

ment so as not to injure the articular face, and a double-acting screw-instrument is applied so as to bring the fragments together. Then a coil of very thin copper wire is firmly wound around the pins, and the screw-instrument is removed.

Occasionally, very bad results have followed these heroic measures. Wyeth¹ relates a case of long standing in which the fragments were sutured; the joint suppurated, and amputation became necessary.

It has been proposed by Ollier, Wyeth,² and others, to insert fresh marrow cells between the fragments; and the plan has been adopted in a few instances, but I believe with only negative results. The theory of such a procedure is difficult to understand; it would seem to be needless if the fragments were close together, and useless if they were widely separated, to say nothing of the want of a physiological ground for expecting any advantage from it in the way of bone-formation.

Dieffenbach³ made a subcutaneous section of the ligamentum patellæ, and of the rectus femoris about three inches above the patella; he then rubbed the fragments together, and kept them in contact by means of an apparatus for parallel pressure; it is said that there was "complete hardening of the interposed substance," and that the patient's condition was markedly improved. One cannot help asking, however, whether the mere solidification of the patella would not be somewhat dearly bought at the expense of a lengthened and weakened ligament, and a muscle impaired by the substitution of a cicatrix for a portion of its substance.

It will now be necessary, in order that the reader may not be only embarrassed by the foregoing enumeration of methods and appliances for the treatment of fractures of the patella,⁴ that I should give a brief and practical summary of the subject. Here, as elsewhere, the great aim of the surgeon is, and ought to be, to restore, as nearly as possible, the normal state of things; and it has, therefore, been thought desirable to obtain bony union between the fragments. But that this is not essential to a good cure has been shown in the facts stated as to the value of limbs in which the fragments were connected only by a fibrous band of considerable length. Hence it may well be questioned whether it is not a mistake to concentrate all our attention upon merely forcing the fragments together, and especially to run any risk of doing greater mischief by the very means employed to this end.

Whenever the fragments have already been forced apart, a tearing of the fibrous tissues surrounding the bone, and in the neighborhood, must have occurred. To prevent any increase of this rending, by properly securing the upper portion of the bone, is manifestly indicated; and in doing this it is equally clear that interference with the nutrition of the bone and of the limb should be avoided. I think that it is sound surgery to use mild means first; and hence should advise the relaxation of the quadriceps muscle by extending the knee, and flexing the hip-joint by elevating the foot. As soon as the inflammatory symptoms of the first few days have been subdued, the upper fragment should be brought down, but not with any great force, and a compress applied above it, with pressure in such a direction as to oppose the upward pull of the quadriceps muscle. For this purpose any of the simpler means above described will answer; I think that the elastic traction of the Middlesex-Hospital plan is perhaps the best, but it should not be too vigorously applied. At the end of six or seven weeks, it will be found that the tendency

¹ Med. Record, June 22, 1882.

³ Casper's Wochenschrift, Oct. 2, 1841.

² Ibid., May 11, 1878.

⁴ The list might have been still further extended, but I have not thought it worth while to include a number of contrivances, which, although published as new, are really only modifications, and often very trifling ones, of existing plans or instruments.

to separation of the fragments no longer exists, and the patient may be allowed to lie in bed with merely a back splint on the knee, and with the limb otherwise unconfined. A week later he may be permitted to sit up, and to move about in a wheel-chair; after which the use of the limb may be gradually resumed, the back splint being left off. It may very probably be that the uniting medium will be found to stretch, and the gap between the fragments to be thus widened; but in time the parts will acquire firmness, and the result will be satisfactory.

In the rare instances in which this does not happen, but the limb remains weak and useless, the propriety of resorting to more energetic means may be considered. I do not myself think that any great risk is run in using Malgaigne's hooks, but I do not think that any great gain is effected by them. And, although much is claimed for the graver procedures, the resection and suture of the fragments, I think that a faithful trial should first be made of the reparative powers of nature, aided by frictions, shampooing, and well-regulated exercise, before the patient is subjected to the hazards which they cannot but involve. Everything else failing, and it being clear that the want of union between the fragments is the sole cause of the disability, extreme measures may be taken; but the patient should be made fully aware of the extent of the dangers attending them, and of the chances of ankylosis, or of still worse evils.

As to section of the quadriceps or its tendon, it seems to me to be merely the substitution of one evil for another. If incomplete, it is useless, while, if complete, it must almost of necessity involve the wounding of the knee-joint.

Compound fractures of the patella are always of grave importance, largely increased if the knee-joint be directly involved. These injuries are always due to direct violence, and the bone is often comminuted. The arthritis which is so apt to ensue upon simple fractures may be looked for in even a higher degree in the cases in question, and is much more likely to assume the suppurative character, as it will almost certainly do if the synovial cavity is laid open to any extent. Gross¹ mentions a case followed by abscess, necrosis, and removal of the patella, the knee-joint becoming partially ankylosed. Levergood² records an instance in which, the patient having been inefficiently treated, and having left his bed four weeks after the accident, suppurative arthritis ensued, and the joint was emptied by incision; amputation was proposed but refused; recovery took place, and the patient was dismissed with "slight ankylosis." Poland,³ among 85 recorded cases, found that 20 proved fatal; suppuration occurred in 63, and ankylosis more or less complete resulted in 31 out of the 65 in which recovery took place.

The *symptoms* are generally sufficiently clear. The *diagnosis* is only obscure, in some instances, in regard to the involvement of the knee-joint, which may be but slightly punctured; sometimes the opening is large enough for the finger to be readily passed in, and in any case the escape of synovia, if abundant enough to be distinctly perceived, is conclusive.

The *prognosis*, it need hardly be said, is to be carefully guarded. If the immediate danger of shock is surmounted, there remain too many chances against both the limb and the life of the patient to warrant the surgeon in presuming upon success. Yet it does sometimes happen that complete recovery takes place, even under apparently adverse circumstances.

The *treatment* is not materially different from that of ordinary simple frac-

¹ Op. cit., vol. i. p. 1004.

² Am. Journal of the Med. Sciences, Jan. 1860.

³ Med.-Chir. Transactions, vol. liii.

tures, except that the wound must be dressed. If small, an attempt may be made to close it; but if large, and if the joint-cavity be opened, I think that thorough washing out with carbolized water should always be resorted to. Afterward, the closure of the wound ought again to be aimed at, as it may be obtained unless suppuration ensue, in which case experience teaches that effective drainage gives the best results; this may be accomplished either with a fine rubber-tube, with horse-hair, or with a few strands of carbolized silk.

As dressings, lead-water and laudanum, carbolized water, or an ice-bag (in hot weather especially) may be employed. Irrigation has been preferred by some surgeons, but cannot always be conveniently arranged so as not to wet the clothing and bed, on account of the position of the limb.

The question of amputation or of excision of the joint must sometimes come up when the patient is young, and the local injury very severe, but it can hardly be appropriately discussed here.

Perhaps it is in these cases that the use of Malgaigne's hooks, or the resort to the suture, is most available; yet I cannot but think that other means should first be tried, and that they will often be found efficient.

Very generally, after the first stage of the case, and especially if suppuration is established, a stimulant and supporting treatment is obviously demanded, and must be kept up during a long and tedious convalescence.

FRACTURES OF THE BONES OF THE LEG.

All authors agree that these injuries are of very common occurrence; but there are some curious differences noticeable between the statistics derived from different sources, as will appear from the following data, chiefly obtained from Gurlt:—

Lonsdale, out of 1901 cases, gives 289, or about 15 per cent. of the leg.

Gurlt, among 1631, found 283, or over 17 per cent.

Blasius, out of 778, found 139, or nearly 18 per cent.

Middeldorpf, out of 325, gives 59, or a little over 18 per cent.

Matiejowsky, among 1086, gives 293, or nearly 27 per cent.

Agnew, among 8667, found 2315, or nearly 27 per cent.

Malgaigne, out of 2328, found 652, or 28 per cent.

Lente, among 1722, gives 579, or nearly 34 per cent.

If the reader will take the trouble to compare these statements with those quoted on page 186 from the same sources, but in reference to fractures of the femur, he will see that the figures given by the different institutions, for the latter bone, are not in the same ratio to one another as those above quoted for the leg. But these discrepancies can only be stated as facts, difficult, it seems to me, of explanation.

Fractures of the leg are divided into those which affect both bones, those of the tibia alone, and those of the fibula alone. These again are found to differ in frequency; both bones being involved far oftener than either bone singly. These differences are marked enough to warrant their presentation in a table as follows:¹—

¹ The percentages in this table have reference to the fractures of the leg only, and in stating them they are given approximately, neglecting fractions.

	Both bones.		Tibia alone.		Fibula alone.	
	197 or 68 per cent.		41 or 14 per cent.		51 or 17 per cent.	
Lonsdale	173	" 61 "	36	" 13 "	42	" 15 "
Gurlt ¹	94	" 67 "	30	" 21 "	15	" 11 "
Blasius	40	" 68 "	8	" 14 "	9	" 15 "
Middeldorpf ²	230	" 78 "	33	" 11 "	30	" 10 "
Matiejowsky	1441	" 61 "	437	" 19 "	437	" 19 "
Agnew	515	" 79 "	29	" 4 "	108	" 15 "
Malgaigne	442	" 73 "	45	" 8 "	92	" 16 "
Lente						

Among the 316 cases derived by me from the records of seven years at the Children's Hospital, there are stated to have been 7, or a little over 2 per cent., of the leg; they are not classed as above, but fractures of either bone by itself are of extreme rarity during childhood, as, indeed, may almost be said of fractures in this region in general. Probably the reason of this may be found in the very slight leverage afforded by the bones of the leg at this period of life, whereas the femur, which is so often broken in children, yields by reason of its slenderness. I have, however, myself repeatedly had occasion to treat fractures of the leg in children in private practice.

It may easily be seen why the proportion of fractures of both bones should be so large. Any force applied to the part, sufficient to break one bone, will be likely to act on both; and if one of the bones gives way, the other, losing its support, will be very apt to give way also.

Fracture of the leg may occur at any age, and in either sex; but the great majority of its subjects are adult males, simply because these are especially exposed to the violence by which the injury is produced. Agnew says that he has twice seen intra-uterine fracture of both bones; and two other cases have been referred to elsewhere.² On the other hand, Meachem³ has reported the case of a woman aged ninety years, who broke her leg in the lower third; union had occurred by the twenty-eighth day.

For greater convenience, fractures of both bones of the leg will first be considered, then those of the tibia, and lastly those of the fibula.

FRACTURES OF BOTH BONES OF THE LEG may be produced either by direct violence, as by blows, kicks, or falls—the leg striking against resisting objects—or by indirect, as when a man falls from a height, alighting on his feet, or when the foot is caught, and the impetus of the body is exerted upon the upper part of the leg. It is not always easy to explain the mechanism of these injuries with exactness, although the general principles of their production can be readily understood. The whole limb constitutes a mechanical system; and if force be brought to bear upon it in such a way that the leverage is through the lower part, for example, of the leg, the foot being fixed, and especially if there be any twist impressed upon the bones at the same time, the bones will give way either where the stress is greatest, or at the weakest point of their structure.

Muscular action has in a very few instances been assigned as the cause of fractures in this region. Agnew⁴ says: "A colored man was brought into the Pennsylvania Hospital with a fracture of the tibia and fibula, four inches above the ankle, which was caused by the violent muscular effort made to recover his equilibrium after slipping upon an orange-peel. He was thirty years of age, of an excellent constitution, and without any evidence whatever of pre-existing bone-disease. He had never before had a fracture." Gross

¹ Gurlt, in his statistics, gives fractures of the malleoli separately; they numbered 32, and thus would be 11 per cent. of his 283 fractures of the leg. Middeldorpf gives 2, which would be about 3.5 per cent. of his 59 cases of fracture of the leg.

² See p. 21.

³ Am. Med. Times, Jan. 5, 1861.

⁴ Op. cit., vol. i. p. 981.

mentions that "an instance of fracture of both bones of the leg by muscular action, in a man forty-two years old, has been recorded by Hevlhard d'Arey." Hamilton says "Eight times I have found the bones broken by muscular action alone."

It does not often happen that both bones are fractured at the same level; very generally the fibula yields at a higher point than the tibia. Sometimes the fractures are very far apart, so as really to constitute separate lesions, as in two specimens mentioned by Stoker.¹ Here the tibia was broken low down, and the fibula high up, the obliquity of the two fractures being in converse directions. These cases, rare as they are, are not without analogues in the forearm. Occasionally the leg is broken in more than one place, when the violence is very great, as in some machinery accidents. Bransby Cooper² saw a case in which both bones of the left leg were fractured in three distinct places; the patient, a man aged forty-eight, had had his leg crushed over the side of a boat by the falling of a heavy weight; amputation was proposed, but he declined to submit to it, and although for a time his symptoms were very threatening, he ultimately did well, his convalescence being considered established by the eleventh week. In a specimen without history, in the Museum of the Pennsylvania Hospital,³ "the shaft of the tibia presents three nearly equidistant, slightly oblique fractures, and several small fragments have been broken off from the bone. There are also three equidistant fractures of the shaft of the fibula, the upper two of which are oblique, the other transverse." A similar specimen is in the Pathological Cabinet of the New York Hospital.⁴ The fibula is "broken near its upper end, while the tibia has been traversed by several very oblique fractures at and below its middle, separating the shaft into four fragments, all of which are firmly united by bone deposited between the opposed surfaces and in the cavities left by projecting angles."

Fractures of both bones of the leg at their upper part are always due to great direct violence, such as the passage of a wheel, the caving in of earth, entanglement in heavy machinery, etc. These fractures may or may not involve the knee-joint, and their exact mechanism is often difficult to determine. When the knee-joint is involved, it sometimes seems probable that the tibia first gave way across its long axis, and then that the lower or shaft portion was forced into the upper, bursting it into two or more fragments. The line of separation is seldom exactly transverse, but it is not often very oblique. Occasionally the fibula escapes; but this is a matter of small moment, not affecting the gravity of the injury, or influencing the symptoms.

In the Pathological Cabinet of the New York Hospital, there is a specimen⁵ from a man, aged thirty-two, who had a compound fracture of the left tibia, caused by a blow from a heavy piece of iron. "Both tuberosities are separated from the shaft by a line of fracture running across the bone an inch or so below the joint, and a small portion of the internal tuberosity is still further separated by a fracture running from the first one up into the joint."

When both bones are broken in the upper thirds of their shafts, the fractures are as a rule oblique, and they are apt to be more nearly on a level with each other than when the injury is lower down. In the latter case, as before stated, the fibula is generally broken higher up than the tibia.

By far the largest number of cases, however, affect the bones of the leg either at or below the middle. I have said that the line of breakage is most generally oblique; yet it is not always so, and one or two specimens of

¹ British Med. Journal, Dec. 24, 1881.

³ Catalogue, p. 42; No. 1174.

⁶ Catalogue, p. 116; No. 226.

² Guy's Hospital Reports, vol. i. 1836.

⁴ Catalogue, p. 122; No. 243.

almost exactly transverse fracture in this region have come under my observation. Tillaux says that one reason why the tibia is apt to break below the middle, is that it has there its least diameter; another, that it there assumes a cylindrical instead of a triangular form; and he mentions a third, "a peculiar arrangement of the bony tissue, pointed out by MM. Fayel and Duret; the cancellous structure of the tibia is, according to these authors, disposed in two independent systems of vertical columns; the one occupies the upper two-thirds, and the other the lower third, so that the minimum of resistance corresponds to the junction of the two systems."

In the middle, or indeed anywhere in the extent of the actual shaft of the bone, if force is applied to the tibia sufficient to break it, and especially if it be indirect, the fibula can scarcely escape: the exceptions being perhaps slight torsion, and such force as the kick of a horse, or any pressure brought suddenly to bear upon the tibia, for an instant only; in such cases the elasticity of the fibula may allow it to yield, and to spring back into shape. Sometimes, indeed, the slenderness of the fibula may exempt it from direct force which breaks the tibia. If the leg is strongly bent between the knee and the foot, both bones may give way at once, or the tibia may be first broken, and the fibula may yield secondarily from the stress put upon it when it is no longer supported by the larger bone.

Holmes¹ figures a specimen in the Museum of St. George's Hospital, showing "the lower epiphyses of the femur and tibia, and both epiphyses of the fibula, separated in the same injury; the shaft of the tibia is also fractured." He quotes also Prof. R. W. Smith's account of a case of separation of the lower epiphysis of the tibia, observed in a boy, aged sixteen, who recovered.

The *symptoms* of this injury are often very distinct. As a general rule, there is immediate loss of power, and the patient falls; but to this there have been noted numerous exceptions. Ormerod² mentions the case of a man aged thirty-two, admitted into St. Bartholomew's Hospital in 1843, who had sustained, by the kick of a horse, a transverse fracture of the right tibia a little below the middle, with fracture of the fibula in its lower third. He had walked to the hospital, consuming about four hours in so doing, with a crutch about the length of a walking stick; his leg was very crooked at the time of his admission. Bryant says, "I have seen more than one patient walk upon the fractured limb directly after the accident, and in one case a man went up a whole flight of stairs to his ward with but a slight limp. In another, under care in 1874, a woman with a fractured tibia and fibula went about for a week." A case is recorded³ of a patient walking about for twelve days after sustaining a fracture of the leg.

Pain is very seldom absent, and may be very severe; there is always tenderness over the seat of injury, or if the limb is grasped above and below, and stress put upon the fractured portion.

The deformity is sometimes very slight, but may be extremely marked; its character depends chiefly upon the fracturing force. When this has been great, the limb may be wrenched entirely out of shape, bent, twisted, and perhaps shortened. But, as will be further detailed hereafter, in some very grave fractures there may be scarcely any change of form.

Prenatural mobility is another symptom which varies greatly in degree in different cases. Sometimes the lower part of the limb dangles in the loosest way, but sometimes the fragments are held together by interdigitations, so that there is very little movement between them.

¹ Surgical Treatment of Children's Diseases, 1st ed. p. 259.

² Clinical Collections and Cases in Surgery, p. 50. London, 1846.

³ Am. Journal of the Med. Sciences, Oct. 1845, from Recueil de Mém. de Méd., de Chir., et de Phar. Militaires.

Crepitus is rarely wanting, and is in general developed by the slightest handling of the injured limb.

Swelling occurs very rapidly, and may mask the other symptoms in a great degree. Ecchymosis also attends almost every case, by reason of the tearing of the periosteum; it often takes place only gradually, and increases for some days. I have repeatedly seen the discoloration of the skin outlast the period of consolidation of the bone. Along with the ecchymosis there is very apt to be a formation of bullæ or blebs, containing a more or less bloody serum; but these, if carefully let alone, will dry away without trouble. They are apt to be a source of great alarm to the patient and his friends, and to inexperienced practitioners.

Gross¹ says that a symptom which is seldom absent is "a spasmodic twitching of the limb, coming on soon after the accident, and frequently lasting for several days, or even weeks, much to the annoyance and distress of the patient." I have never had my attention called to this phenomenon unless other symptoms of disorder of the nervous system were also manifested.

The *course* of these fractures is subject to like variations. In some cases, after the first dressing, there is no pain, union takes place promptly, and the patient's only inconvenience is in the confinement necessarily imposed upon him. Sometimes, however, very grave symptoms manifest themselves. Mr. Green² reports a case of simple fracture of the leg followed by gangrene, for which amputation was performed, with a fatal result; the autopsy showed no wound of the vessels, which may, however, have been pressed upon by one of the fragments. The patient was a man aged forty-seven. Another case is reported by Trask.³ Dupuytren⁴ records six cases in which arteries were wounded by the fragments, the anterior tibial, the posterior tibial, and the peroneal being known to have thus suffered. Three times amputation was called for, and twice ligation of the femoral. Leigh⁵ records the case of a man, aged forty-eight, who fell from a height, and fractured both bones just below the knee. On the twentieth day he was thought to have an abscess, which was punctured, but only blood escaped; two days afterward the wound was opened, and the anterior tibial artery was found torn across. The vessel was tied, but death occurred in a few hours. Borchheim⁶ has published an account of a case of fracture of both bones, in which an aneurism of the posterior tibial artery was formed, and the femoral was tied at the apex of Scarpa's triangle; union was not interfered with. Edwards⁷ has reported to the Pathological Society of London, the case of a woman, aged sixty-three, who was run over, sustaining a fracture of the right tibia at the junction of the middle and lower third. On the third day some bullæ appeared on the foot; on the fifth day the foot was cold; amputation was performed, but death ensued. "The anterior tibial vessels had been occluded by being nipped between the fragments; and a large blood-clot was found in the calf, pressing on the posterior tibial vessels." Stimson⁸ says that Nepveu in a recent paper,⁹ cites more than fifty cases of fracture involving injury to various vessels in the leg. Occasionally the nerves are likewise injured. Callender¹⁰ records four cases of this kind, in which bullæ, causalgia, glazed skin, and the other phenomena recognized as due to nerve-lesions, were present.

¹ Op. cit., vol. i. p. 991.

² St. Thomas's Hospital Reports, vol. i. 1836.

³ Am. Journal of the Med. Sciences, Oct. 1850.

⁴ Lesions of the Vascular System, etc.; Syd. Society's Translation.

⁵ St. George's Hospital Reports, vol. iii. 1868.

⁶ Medical Record, Dec. 30, 1882.

⁷ Med. Times and Gazette, May 26, 1883.

⁸ Treatise on Fractures, p. 568.

⁹ Bulletins de la Soc. de Chirurgie, 1875.

¹⁰ St. Bartholomew's Hospital Reports, 1870.

It must not be forgotten that fat-embolism, of which mention was made at some length in the early part of this article, is especially apt to ensue upon fractures of the leg, in which the conditions upon which that pathological process depends are more fully met than in fractures of any other part of the skeleton.

A peculiar form of fracture, affecting, almost if not quite exclusively, the lower part of the leg, was described with much accuracy by Gosselin,¹ nearly thirty years ago. Both bones are broken; but it is the lesion of the tibia which is important. This bone yields to a force of which torsion is a principal element, according to some observers the only one; but I think that there is ground for believing that there is first a flexion or cross-breaking strain. However this may be, the tibia sustains, first, a V-shaped fracture, the apex of the V presenting downward, and in some, if not in all the cases, on the antero-internal face of the bone, instead of along its crest. From this apex, or from a part of the V close to it, there runs downward a fissure, always in a spiral direction, to cross the ankle-joint, from behind forward, and then to run upward and join the main fracture at some other point. I think that the mode of production of this fissure will at once suggest itself in the lateral pressure of the apex of the V against the sides of the corresponding part of the lower fragment. This is the explanation admitted by Tillaux,² who has given a very clear and practical discussion of the whole subject. These fractures have been designated as V-shaped, wedge-shaped, spiroïd, or helicoid; but none of these terms adequately describe them. The V-shaped portion is of importance only as, under torsion, causing the fissure; it does not act as a wedge; "spiroïd" is at best a mongrel word, and neither it nor "helicoid" is suggestive of the very long and really but slightly curved line in which the bone splits. Tillaux thinks the phrase "oblique fracture of the leg" a good one, with the addition, if another epithet be required, of the word "helicoid." I venture to suggest that "Y-fractures of the tibia" would convey the idea of the essential features of the lesion.

Hulke³ says that the fracture of the fibula, in these cases, always has more or less of the V-shape; and that this bone sometimes gives way at more than one point. Tillaux gives an instance in which it remained intact.

There are obvious reasons why fractures of the kind just described should be attended with danger of serious consequences. Besides the involvement of the ankle-joint, the damage done to the bone itself is extensive, and the medulla can scarcely escape bruising, hemorrhage into its substance, and interference with its nutrition. Hence, arthritis, osteo-myelitis, pyæmia, or septicæmia, may ensue, and cost the patient his life. Yet these risks are often successfully met, as in cases recorded by Gosselin. Two specimens are known to me, one in the Mütter Museum and the other in the Wistar and Horner Museum at the University of Pennsylvania, in which union has taken place in a very perfect manner, the line of the fractures, however, being clearly traceable.⁴

Fractures of the leg at its lower part have been sometimes said to be analogous to those at or just above the wrist; but it seems to me that this idea is apt to lead to error. Supra-malleolar fractures are in some small degree similar to those of both bones of the forearm close to the wrist; but even here the resemblance is but slight and superficial.

¹ Gazette des Hôpitaux, 1855; Mém. de la Société de Chirurgie, tome v. 1855; and Bulletin de la Société de Chirurgie, tomes vi. et ix. See also Clinical Lectures on Surgery, translated by Stimson, pp. 90 *et seq.*

² Op cit., p. 1149.

³ Holmes's System of Surgery, vol. i. p. 1043.

⁴ For further information in regard to these fractures, the reader is referred to the articles and works before quoted; also to an interesting paper on the subject, by Dr. R. M. Hodges, in the Boston Med. and Surg. Journal, Jan. 11, 1877.

The ankle-joint is a hinge, with no other motion except a very slight possible rotation of the foot in extreme extension. The astragalus is keyed or mortised between the malleoli, and if the foot is fixed, the leverage which may be exerted from above through the leg is very powerful. According to circumstances not easy to define, the stress may be brought to bear either upon both bones just above the ankle, or upon the inner malleolus and the lower part of the fibula. The outer malleolus sometimes suffers, as will be shown in speaking of fractures of the fibula alone.

Supra-malleolar fractures may be due to direct violence, or to a wrenching by outward or inward movement of the knee when the foot is fixed, or, as I believe, in some cases to extreme extension or flexion of the ankle, the foot being fixed. I have several times seen, in persons who had fallen from heights, alighting on the feet, fractures which seemed to be explicable in the latter way alone.

Fracture of the inner malleolus, with fracture of the fibula at some point generally about three inches above the ankle, is commonly known as Pott's fracture, having been first described with accuracy by the distinguished surgeon of that name. It had previously been regarded either as a sprain or as a dislocation.

Although, as I shall presently further show, this lesion varies greatly in different cases, there are certain features which always belong to it and distinctly characterize it. There are two ways in which it may be produced. When the foot is strongly everted, so that the sole looks outward, the internal lateral ligament is put upon the stretch, and a cross-breaking strain is brought to bear upon the inner malleolus, which gives way. As soon as this happens, the astragalus and calcaneum are forced up against the end of the fibula, which bends and breaks, generally at a point some three inches above. On the other hand, if the foot is strongly inverted, so that the sole looks inward, the inner malleolus may be, as it were, pushed off, while the outer malleolus is drawn inward, and the fibula gives way to stress tending to bend it outward.

In either case, the force is brought to bear across the columns of the cancellous tissue of the inner malleolus, while the point at which the fibula generally gives way is where it is slenderest and least able to resist.

By way of illustrating the differences presented by the lesions in these cases, I may simply quote the descriptions of three specimens in the Pathological Cabinet of the New York Hospital.¹ In one, taken from a man aged thirty, injured by the caving in of a bank of earth, "the fibula is seen to be fractured transversely two inches above the joint; the internal malleolus is torn off, and the posterior margin of the articular surface of the tibia is broken into three pieces."

In another, "the internal malleolus is broken off, and the fibula is fractured obliquely one inch above its lower end." No history of the case is given.

In the third, taken from a man aged fifty-three, who made a mis-step and fell upon the pavement, "there was a fracture of the fibula, commencing at the level of the ankle-joint, and running so obliquely upward and backward as to leave a fragment nearly three inches long connected with the astragalus. The internal malleolus was torn off, and the whole of the posterior third of the articulating surface of the tibia was comminuted and broken off by a fracture running upward and backward from within the joint, thus leaving several large fragments still attached to the astragalus below."

Occasionally the portion detached from the tibia is very small, consisting merely of the tip of the malleolus; and the lesion may then be properly ranked among "sprain-fractures."

The *symptoms* of the fractures now described are placed together here by

¹ Catalogue, p. 119; Nos. 233, 234, and 235.

way of contrast. Those of the "V-shaped fracture" are: projection, but not generally very marked, of the upper fragment; pain, utter loss of power, swelling, ecchymosis; mobility and crepitus only at the seat of the oblique fracture, the bone as a rule not being noticeably separated at the fissures. General tenderness always exists along the whole course of the fracture. Effusion occurs rapidly into the ankle-joint.

Fig. 844.



Deformity in "Pott's fracture."

In "Pott's fracture" there is generally very marked deformity, the ankle being bent as in the cut (Fig. 844), and very movable until effusion has taken place in the joint. Ecchymosis occurs gradually.

Fractures of the lower portion of the leg, involving both bones, usually unite well, although some cases of non-union in this region are upon record, and sometimes consolidation

takes place but slowly. In cases of Pott's fracture, unless the deformity is effectively remedied by treatment, the ankle remains permanently distorted, in a position similar to that of talipes valgus, and for a long time there is serious difficulty in walking. Sometimes, however, even when the bones have united in bad position, there is ultimately a much better result than might have been expected.

The *treatment* of fractures of the leg has long been recognized as a matter of great importance, and to describe all the contrivances for the purpose which have been brought forward would be a formidable task. I shall endeavor to give an idea of the principles to be carried out, and of the chief methods proposed for so doing, dwelling especially upon those which are of most practical value.

As in most other fractures, the main points are the correction of the deformity, the restoration of the normal shape of the part, and the maintenance of the limb in this condition until the fragments shall have become firmly united.

Sometimes the reduction is accomplished with ease, but sometimes it presents great difficulties. When the fragments are very loose, the distal portion of the limb dangling and very movable, the replacement is, as a rule, easier than when, though the displacement is less marked, the two portions of the tibia are interlocked. Very oblique fractures are sometimes attended with great overlapping, but this may be rectified without much trouble; its recurrence, however, can scarcely be obviated, except by well-adapted means, carefully applied.

Angular deformity is in general overcome by gentle manipulation, and ought not to be permanent under proper treatment. The rotation of the lower portion of the leg outward or inward must be carefully corrected, and in so doing the surgeon should make sure that both bones are placed in proper line; otherwise the tibia may be straight, but the fibula bent so as perhaps to give the patient a limp in his gait.

It will readily be seen that the reduction should be effected at the earliest possible moment, for two reasons: in the first place, because the swelling which soon ensues increases the difficulty of the procedure, and prevents the surgeon from judging how far he has succeeded in accomplishing his object; and secondly, because the resistance of the muscles is greater the longer the

fragments have remained in their false position. Muscular action is not the sole cause, often not even the chief cause of the deformity, which is in general due to the fracturing force, or to the weight of the parts; but it very commonly is an obstacle to its correction. Hence this process is facilitated by relaxing the muscles, which is done by flexing the knee, and slightly extending the foot. Fractures which cannot be reduced at all with the knee straight will often yield promptly as soon as it is bent.

The test of the limb being in proper line is that the inner edge of the patella, the inner side of the ankle, and the inner side of the great toe, are in the same vertical plane. And the fingers passed along the tibia should detect no angular irregularity in its surface.

I have said that the main difficulties in reduction are due to interlocking of the fragments of the tibia, and to muscular contraction. Sometimes the condition of things is more complicated, and may be very obscure:—

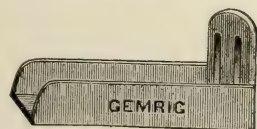
A woman, aged fifty, was brought into St. Joseph's Hospital, Philadelphia, having been run over by a wagon which had produced a severe compound fracture at the upper part of the right leg; reduction was impossible, although the most apparent obstacle was removed by cutting off the end of the upper tibial fragment, which protruded through the skin. Eight days afterward, amputation being performed through the knee-joint, it was found that the upper end of the lower fragment of the fibula was wedged in between the upper fragments of both bones, and that this had constituted the difficulty in replacement.

The reduction being effected, some surgeons are willing to trust for its maintenance to the pressure of a pillow, lapped around the limb and tied about with tapes or strips of bandage. Although this plan has been sanctioned by some high authorities,¹ I have never myself seen a case in which I should have felt justified in using it, except as a temporary resource.

Plaster bandages, the Bavarian splint, and other forms of solidifying dressing, have found many advocates within the last forty years, since the revival of this method by Larrey and Seutin. One objection holds against every form of it as a primary dressing for fractures of the leg, namely, that it prevents the constant inspection of the limb which can alone assure the surgeon that it is properly kept in shape. Skilfully applied, and carefully watched, I do not believe that the immovable apparatus is likely to do any harm by constricting the limb, although under other circumstances serious trouble has arisen in this way. At a later stage of the case, when the union between the fragments has become somewhat firm, a plaster or silicated bandage, or the Bavarian splint, may be employed to great advantage, enabling the patient to sit up, and to move about on crutches.

The "fracture-box" is an appliance which has long been used in the Pennsylvania Hospital, and which has some great merits. It consists of a board, having two sides attached by hinges, and a foot-piece. (Fig. 845.) The sides being let down, a pillow is laid in the box; the leg is carefully adjusted in the pillow, and the foot secured by a strip of wide bandage passed under the heel, its ends being then crossed over the instep and put through two slits in the foot-piece, to be tied at its outer side. Now the sides of the box are brought up, pressing the pillow against the leg so as to give it uniform and complete support. Of course, the size of the box must be adapted to that of the limb. If the fragments tend to form an angle forward, the heel can be raised; if backward, it can be lowered.

Fig. 845.



Fracture-box with movable sides

¹ Skey, *Lancet*, Jan. 9, 1864; Wicks, *British Med. Journal*, Nov. 25, 1882; Duke, *ibid.*, Dec. 16, 1882. Sand-bags are generally added in order to promote the steadiness of the limb.

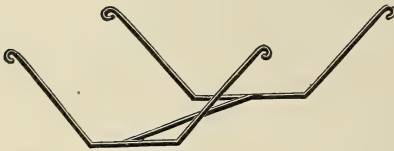
In England, the splint known as McIntyre's or Liston's has been very largely used, generally with a Stromeyer screw for the purpose of changing the angle of the knee when desired; and the ordinary double inclined plane has also been employed, not only by British surgeons, but on the continent of Europe and in this country. I think, however, that although there can be no question of the fact that good results have been obtained by such means, the want of more effective lateral pressure than is likely to be made by a mere bandage, and the uncertainty of posterior support through the muscles of the calf, make these forms of apparatus less available for general use than might be supposed from the reputation accorded them.

Lateral support, indeed, seems to me to be of prime importance in the treatment of the injuries in question; and my own practice is to employ it sedulously in every case. For this purpose I prefer moulded splints of binder's board, gutta-percha, or sole-leather, accurately adapted to the limb, properly lined or padded, and secured by careful bandaging, so as to control the leg and foot as perfectly as possible. Pressure upon the bony points, the head of the fibula, the malleoli, and the tarsal bones in very thin persons, must be guarded against by cutting out holes in the splints, and all the edges must be nicely bevelled. The side-splints should extend up along the side of the foot, so as to keep it steady and in line; but they should not reach so high as to interfere with the free flexion of the knee.

Patients with fractures of the leg are rendered far more comfortable by having the injured limb suspended, so that it can move freely without dis-

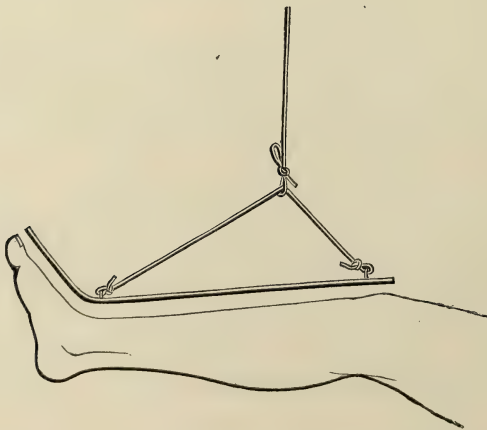
turbing the fragments. By this arrangement they are enabled to sit up, and even to be out of bed, with perfect safety. When the fracture-box is used, it may be hung in a frame (Fig. 846) by means of cords attached to the ends of the arms; the frame should be made of iron bars stiff enough to sustain the weight without bending. When the lateral splints are employed, I prefer suspension by means of a

Fig. 846.



Frame for suspending fracture-box.

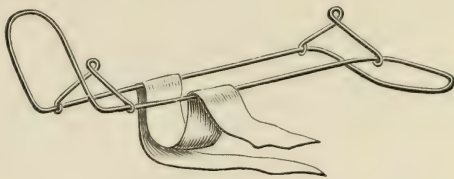
Fig. 847.



Wire frame for suspending leg.

wire frame like Smith's splint, using only the portion corresponding to the foot and leg. (Fig. 847.) In this frame the leg may be cradled by double strips of bandage, tied or pinned. (Fig. 848.) To attach the suspension apparatus, I use a support consisting of a wooden upright about six feet high, having at its top an arm at right angles, into the under surface of which is screwed a pulley; its lower end is set in a tripod, one long foot extending out parallel with the upper arm, and the other two at right angles to it. The long foot goes under the bed. A cord run through the pulley, with a tent-block, serves to attach the cords connected with the suspension-frame. From this description, I think the working of the whole apparatus may be readily understood. By having the gallows-frame unconnected with the bed, it may be moved to another part of the room, and the patient may be dressed and sit up, with his leg securely swung.

Fig. 848.



Mode of supporting leg with strips of bandage.

I may here mention that I have sometimes had occasion to move patients with fractures of the leg, and have found that they can bear the motion of a carriage or railroad train with perfect ease, by having the injured limb, properly splinted, laid on strips of rubber bandage nailed across a wooden frame supported on sides like those of a box.¹

Other devices for suspension have been employed. Salter's swing is well known in England. The late Dr. Hodgen² published a description of a swinging fracture box, which was only open to the objection that, in order to let down the sides, the whole box had to be lowered and placed upon the bed. Dr. Nathan R. Smith's apparatus for fracture of the leg, consisting of a thigh piece, with a frame for the leg, and a foot-piece, is well known, and had a somewhat extensive popularity at one time. I do not think that it is largely used at present—perhaps, because it has been superseded by simpler and apparently more secure contrivances.

By some of the older surgeons it was advised that the limb should be laid on its outer side, secured by slips of wood bandaged so as to steady the bones, and with the muscles relaxed by bending the knee. Such a position would no doubt be comfortable, but it may be doubted whether the proper coaptation of the fragments would be effectively maintained. Yet it is spoken of with approval by Hulke,³ as adapted to some cases in which "there is a tendency to displacement of the fragments when the leg is straightened." I cannot but think that suspension of the leg would answer the same purpose, with less risk of displacement.

Cases sometimes present themselves in which extension and counter-extension are required to counteract the tendency to shortening. Swinburne,⁴ indeed, advocates the treatment of all fractures of the leg by this means alone, without splints or other means of lateral support; but I do not think that he has had many converts to this peculiar, and in my opinion dangerous, doctrine. Reference has been already made to the fact that Sands, St. John, and some

¹ An arrangement of this kind is figured by Benjamin Bell (*System of Surgery*, Edinburgh, 1788. Plate lxxiii. Fig. 3), but with straps and buckles, and without any elastic support; it is described as an apparatus for compound fractures, to admit of the dressing of a wound without disturbing the limb.

² St. Louis Med. and Surg. Journal, March 10, 1871.

³ Holmes's *System of Surgery*, 3d ed., vol. i. p. 1046.

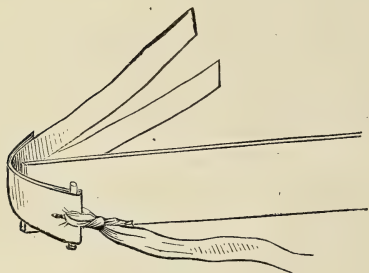
⁴ Op. cit., p. 25.

others, have thought that a sufficient degree of extension was effected, even in fractures of the thigh, by firm lateral support and compression; this they would obtain by bandaging, with or without plaster of Paris, the limb being placed in such a posture as to relax the muscles. The experience of most surgeons, however, would lead them to seek more direct methods, in cases where shortening was seriously threatened; and a variety of appliances have been proposed and employed for the prevention of this evil, chiefly modifications of those already described in connection with the treatment of fractures of the thigh.

The method which I myself employ consists in the use of adhesive plaster, with the side-splints already spoken of.

Extension may be made by means of the side-splints, as follows: Four strips of adhesive plaster are cut lengthwise of the piece, and of length and breadth corresponding to the size of the limb—for an adult, about eighteen inches long by two inches wide. Each of them is then split up from one end for about half its length; the end which remains whole is next folded on itself,

Fig. 849.

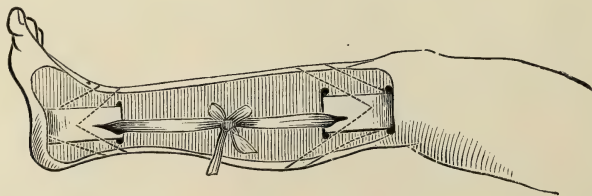


Side-splint for making extension in fractures of the leg.

the adhesive surfaces in contact, and a small slip of wood is placed in the loop so made. A slit is now cut close to the bit of wood, through which a loop of bandage may be passed. The split ends being applied so as to embrace the ankle below and the upper part of the leg above, the strips are brought round the ends of the splints, and the corresponding pairs tied together on the outside of the latter. Extension is made by the two lower strips against counter-extension by the two upper, the force being increased or lessened by drawing the strips of bandage more or less tightly.

This plan I have employed especially in cases of fracture near the ankle-joint, but I think that it will be found effectual whenever the bones are broken, at whatever point, so obliquely as to threaten overlapping and consequent shortening of the limb. It may be better understood by a reference to the cuts, Figs. 849, 850.

Fig. 850.



Extension-splint adjusted.

A marked projection forward of the upper fragment of the tibia is sometimes observed, in cases especially where the fracture of this bone is very oblique. By elevating the heel, this prominence is, generally, almost if not altogether made to disappear; or perhaps it would be more correct to say that the lower fragment is thus caused to follow the upper, so that they are

restored to their normal relation. Care must be taken not to overdo this, so as to produce an angle salient backward, which would give rise to most troublesome lameness. Ormerod¹ records two cases in which this anterior displacement was not manifested for some time after the receipt of the injury; under such circumstances it would seem attributable to defective treatment.

Section of the tendo Achillis, according to Malgaigne, was first proposed and employed as a remedy for this condition by Laugier. It would seem to have found more favor in England² than elsewhere; a case has very recently been reported by Bryant,³ in which the operation was attended with success.

Malgaigne proposed, for the correction of this deformity, the use of a steel point on a screw stem, passed through the centre of a bow of metal, which could be fastened to the back splint by means of a strap and buckle; the bow being placed over the limb a little above the seat of fracture, the point was carried down through the skin, and screwed in so as to produce the requisite amount of pressure. An equally efficient and safer plan would be to substitute for the point a little plate carrying a pad. By slightly shifting the point of pressure from time to time, all risk of its injuring the skin could be readily avoided. I am not aware that Malgaigne's contrivance has ever been used, except in the very few instances mentioned in his work; and, indeed, nature does so much, in the way of rounding off projecting points of bone, that it would seem to me needless to interfere, unless the deformity were more marked than in any case that has ever come under my notice.

A curious consequence of fracture of the leg has been recorded by Terrier;⁴ two months after the injury, a small cyst-like tumor showed itself on the inner surface of the limb near the fracture, and proved to contain free oil, effused from the broken bone; it was evacuated, and finally disappeared.

Pseudarthrosis is not uncommon after fracture of both bones of the leg. In Agnew's tables,⁵ out of 685 cases, 100, or nearly 15 per cent., were in this region. In thirty-one of these the exact seat of fracture is not given; in one it is said to have been at the junction of the upper and middle thirds; in twenty-four at the middle; in six in the middle third; in nine at the junction of the middle and lower thirds; and in twenty-nine in the lower third. Hence it would appear that non-union is met with, in both bones, very nearly as often in the lower third of the leg as in the middle third; but the fact that in so large a proportion out of the whole number the exact seat of the lesion is not stated, prevents the drawing of absolutely positive inferences upon this point.

The treatment of this condition has been sufficiently discussed in a previous part of this article.

Union with deformity has been observed in a large number of cases of fracture of both bones of the leg, and is often productive of such total disability as to demand surgical interference. In not a few of these cases it has happened that the callus has yielded after the patients have begun to walk, and in almost all there has been a progressive increase of the bending of the limb. When the shafts of the bones are concerned, the angle is almost always salient anteriorly; I know of only a few exceptions to this rule, in which the bones projected backward. Toward the lower part of the leg, the deformity is, for the most part, like that of talipes valgus, the upper tibial

¹ Op. cit., p. 54.

² See Med.-Chir. Transactions, vol. xxxiii. 1849, and Guy's Hospital Reports, 1855.

³ Lancet, June 2, 1883.

⁴ London Med. Record, Oct. 15, 1878, from Revue Mensuelle de Médecine et de Chirurgie, No. 7, 1878.

⁵ Op. cit., vol. i. pp. 752 *et seq.*

fragment projecting inward, and the outer side of the foot being drawn up. In some recorded cases there has been atrophy of the bones also.

The procedures resorted to for the relief of this condition have been of various degrees of severity. Norris¹ quotes Dupuytren² as authority for the use of combined pressure and extension, and cites a case thus treated with success by M. Desgranges, four months after the receipt of the injury.

Forcible refracture has been found effectual. Malgaigne cites cases from Bosch and Oesterlen, and one has been reported by Mussey.³ In 1851, I witnessed the performance of an operation of this kind, by Dr. W. E. Horner, on a leg broken twelve weeks previously; the result was perfectly successful.

Brainard⁴ made refracture easier by first drilling the bones at the abnormal angle; ten days afterward the callus yielded readily, and a good result was obtained. Hunt⁵ resorted to similar means, and with ultimate success, although the patient's life was for a time in great danger.

Section of the callus was first performed, according to Malgaigne, by Oesterlen in 1815; afterwards by Dunn,⁶ Portal,⁷ Key,⁸ Barton,⁹ Mütter,¹⁰ and Josse.¹¹ Norris mentions that he knew of similar operations by Warren, of Boston, and Stevens, of New York; and cites one by Rynd, of Dublin. I myself witnessed one such operation by the late Prof. Joseph Pancoast, and believe that he had others, never published.

The modern method of subcutaneous osteotomy, which seems admirably adapted to the treatment of deformed union in some situations, cannot be so readily employed in cases affecting the leg, for obvious reasons, unless the chisel is substituted for the saw. Dr. Fenger, of Chicago, has published¹² accounts of three cases in which he obtained success in this way. Another was reported,¹³ and the patient, a man fifty-eight years old, shown to the Leeds and West Riding Medico-Chirurgical Society, by Mr. Jessop, of Leeds; the case was one of Pott's fracture, which had firmly united in such a position as to render the limb useless. A section was made through the fibula, 2½ inches above the ankle, and another through the base of the inner malleolus; and union was obtained so that the limb became straight and useful.

Compound fractures of the leg are always serious injuries, and are of very common occurrence in hospital practice. The damage to the soft parts may be due to the fracturing force, as in railway accidents; or it may be produced by efforts to walk on the part of the patient, by which the broken ends are thrust through the skin. Occasionally, the displacement being irreducible, the skin gives way over the projecting fragments, and a fracture at first simple becomes compound subsequently. Sometimes the fracture of one of the bones only is compound, that of the other being simple.

Often in these cases the question of amputation presents itself, and must be settled upon principles elsewhere laid down. If the attempt to save the limb be decided upon, I think it right to cleanse the parts thoroughly with carbolized water; reduction should then be accomplished, the wound closed, but with suitable provision for drainage,¹⁴ and dressings applied. I prefer hot

¹ Contributions to Practical Surgery, p. 113.

² Injuries and Diseases of Bones, Syd. Soc.'s translation, pp. 63, 66, and 68.

³ Am. Journal of the Med. Sciences, April, 1851.

⁴ Chicago Med. Journal, Jan. 1859.

⁵ Philadelphia Med. Times, Oct. 26, 1872, and Surgery in the Pennsylvania Hospital, p. 151.

⁶ Med.-Chir. Transactions, vol. xii. p. 181.

⁷ Am. Journal of the Med. Sciences, Oct. 1841, from an Italian Journal.

⁸ Guy's Hospital Reports, 1839.

⁹ Med. Examiner, Jan. 8, 1842.

¹⁰ Am. Journal of the Med. Sciences, April, 1842.

¹¹ Quoted by Malgaigne.

¹² Medical News, April 15 and 22, 1882.

¹³ British Med. Journal, April 14, 1883.

¹⁴ See an excellent article by Markoe, on Through-drainage in Compound Fractures of the Leg, in the Am. Journal of the Med. Sciences, April, 1880; and a paper by Dr. E. Mason, with its discussion by the New York Surgical Society, in the Medical News, Jan. 7 and Jan. 14, 1882.

water, hot laudanum, or laudanum and lead-water. The fracture-box answers admirably in these cases, but my own practice is always to suspend it, not only because the patient is thus rendered more comfortable, but because the fragments are thus less likely to become displaced.

At a later stage, when, as very generally happens, suppuration ensues, and especially if the discharge be profuse, the bran-dressing devised by the late Dr. J. R. Barton is of great value. It is applied by means of a fracture-box, in which is placed a lining of muslin on which the bran is heaped, making a bed for the limb, which is then covered over with more bran, and the sides of the box brought up. It is not always necessary to secure the foot to the foot-piece, but it is better to do so if suspension is to be used. At this stage patients are apt to have become accustomed to confinement, and to have learned to lie perfectly still.

Bracketed splints of various forms, intended to control the limb while leaving the wound exposed for the purpose of changing the dressings, have been devised. Their value depends entirely upon the accuracy of their adaptation to the size and shape of the limb in each case; and it seems to me safer for most practitioners to rely upon simpler means.

As soon as the wound has healed, or the fragments have been so covered up by granulations as to be no longer exposed to the atmosphere, the lesion assumes the character of a simple fracture, and much of the danger is set aside. In the former case, the side splints, moulded to the limb, or the immovable apparatus, may be resorted to; but care should always be taken lest by undue or misplaced pressure the soft parts should be irritated, and fresh mischief ensue.

Various circumstances may arise in the course of cases of this kind requiring special interference. Extreme swelling and tension of the soft parts sometimes come on within a few hours of the injury, and may be greatly relieved by free incisions. Hemorrhage may occur to an extent that demands the use of prompt and thorough means for its control. At a later period, there may be burrowing of pus along the limb; and counter-openings, drainage, and properly applied pressure may be needed.

FRACTURES OF THE TIBIA alone are, according to some observers, much less frequent than those of the fibula alone; but the statements of others are decidedly at variance with this, as may be seen by a glance at the table quoted from Gurlt on a preceding page. The widest difference exists between the figures given by Malgaigne, 29 of the tibia to 108 of the fibula, and those of Blasius, 30 of the tibia to 15 of the fibula.

When the tibia is broken of itself, it is generally by direct violence, but sometimes by indirect. One instance has been recorded by Caspary,¹ in which it was thought that the bone had yielded to muscular contraction, in a strong healthy man of twenty-six; but as he had had a venereal sore six years previously, and had complained of rheumatic pains for some time before the occurrence of the accident, it seems probable that the texture of the bone may have undergone pathological change.

The fracture may be but slightly oblique; it is seldom as markedly so as when both bones give way. I have met with three recorded instances of incomplete fracture of the tibia. One, quoted by Malgaigne from Campagnac, was that of a girl, twelve years old, run over by a cabriolet; at her death the lesion just stated, with a curvature of the fibula, was ascertained by dissection. Gray² reported to the Boston Society for Medical Improve-

¹ Berl. klin. Wochenschrift, 28 Jan. 1867.

² Am. Journal of the Med. Sciences, Oct. 1853.

ment the case of a boy of six, who "was standing on an iron rail fence, and in trying to jump down was caught by the heel and left hanging in that position;" the subsequent deformity, without crepitus, and the straightening of the limb by means of splints, seemed to warrant the diagnosis given, which, however, could not be absolutely verified, as the patient recovered. The third case was observed by Menzel,¹ of Trieste, in a man aged forty-eight, who was run over. There was some elastic mobility of the bone; the patient died of pyæmia, and "the left tibia was found partially fractured between the inferior and middle thirds; about seven-eighths of its substance was divided transversely; the remainder presented not even a trace of fissure."

Sometimes, although the main line of fracture is nearly transverse, there are subordinate breakages, making a comminution of the bone. James² has recorded a case of longitudinal and transverse fracture of the tibia, with extensive extravasation of blood into the tissues of the leg.

Epiphyseal disjunctions have been observed in the tibia: Madame Lachapelle's case, in which the lower epiphysis of the femur and the upper of the tibia were detached in the delivery of a child, has been already mentioned, as has one of separation of the lower epiphysis of the tibia, quoted by Holmes from R. W. Smith. Stimson³ has reported to the New York Surgical Society the case of a child, aged eighteen months, run over by a horse-car, in whom the upper epiphysis of the tibia was cleanly separated; the upper end of the shaft was denuded of periosteum, which was adherent to the epiphyseal fragment. A specimen of separation of the upper epiphysis of the tibia, from a crush of the leg which required amputation, is figured by Ashhurst.⁴ The original is in the Museum of the Episcopal Hospital. Another case, in a boy of seventeen, has been placed on record by Quain;⁵ the lower epiphysis was detached, the boy falling with his foot doubled under him. Martin⁶ reports a case of compound separation of the lower epiphysis of the tibia, which may be mentioned here, although the fibula was also fractured about four inches above. The patient, a German boy, eleven years old, fell from about half the height of a telegraph pole. "The distal end of the shaft of the tibia had been separated from the epiphysis, and was protruding through the integuments. It had been thrust into the hard frozen earth, friction with which had stripped the periosteal covering of the bone from its entire external surface for the space of at least one and three-quarter inches. The peculiar stellate radiations of the extremity of the shaft where it joins the epiphysis were found to be perfect, when the dirt which had been packed into them had been removed." The boy recovered perfectly in two months.

Reference has already been made, in the early part of this article,⁷ to "sprain fractures." Besides the instances there mentioned, a very instructive account is quoted by Hulke⁸ from Dr. Hutton, with a representation of the specimen, of detachment of the spine and central portion of the head of the tibia, with part of its left articular surface, the fragment remaining adherent to the anterior crucial ligament. The injury was sustained in wrestling.

The *symptoms* of fracture of the tibia are not always very marked. Although the uninjured fibula is not strong enough to sustain the weight of the body, it is sufficiently so to prevent any great separation between the fragments of

¹ London Med. Record, May 27, 1874; from Gazz. Med. Ital. Lomb., 28 Marzo.

² Australian Med. Journal, 1882; quoted in Index Medicus for May, 1883.

³ Med. Record, July 15, 1882.

⁴ Principles and Practice of Surgery, 3d ed. page 269, Figs. 132, 133. Philadelphia, 1882.

⁵ British Med. Journal, Aug. 31, 1867; Holmes's System of Surgery, 3d ed., vol. i. p. 1039.

⁶ Boston Med. and Surg. Journal, Sept. 27, 1877.

⁷ See page 19.

⁸ Holmes's System of Surgery, 3d ed., vol. i. p. 1039; the original account is in the Dublin Hospital Gazette for 1846.

the tibia, and the deformity is hence limited. Some projection of the edge of one or the other fragment, generally the upper, can be felt on passing the fingers along the bone, and this is apt to be more marked, the nearer the fracture is to either end of the bone. Hays, however, has reported¹ a case of fracture of the internal malleolus, clearly defined, without any displacement. The pain is for the most part severe enough to forbid attempts at standing or walking. Crepitus may be felt, and decidedly, although the fragments may be but slightly movable upon one another. Swelling and ecchymosis are apt to ensue, just as in fractures of both bones; and even although the fibula is not broken, it may be bruised, so that this symptom will present itself on the outer side of the leg as well as in the neighborhood of the more serious injury.

The *diagnosis* may be made out clearly enough as regards the fracture of the tibia, but it is by no means always easy to determine whether or not the fibula has been given way. On this point it will be better for the surgeon to restrain his curiosity; if mobility be not at once detected, it should not be vigorously or persistently sought for. In any case of doubt, the prudent course is to assume the probability of fracture.

When the tibia alone is broken, the *treatment* is essentially the same as that of fracture of both bones, and need not be again detailed. Non-union is very rare in these cases, by reason of the support, slight as it would seem to be, afforded by the unbroken fibula; yet Schüller has reported² an instance in which this condition was due to the interposition of the tibialis anticus tendon between the fragments; the patient, a healthy German woman, aged forty, had been run over by a wagon; subperiosteal resection was performed, and afterward the periosteum was sutured, with the result of obtaining complete bony union, with very little shortening, in four months. Sometimes consolidation takes place very rapidly. Schweich³ relates the case of a peasant, aged forty, whose tibia was fractured transversely at about its middle, producing obvious displacement. A starched bandage was applied, and the reporter ceased his attendance on the sixth day. The patient walked in his room on the twelfth day, and returned to his work on the fourteenth. On the twenty-fifth he called on his surgeon, and exhibited a well-formed callus.

FRACTURE OF THE FIBULA alone may be produced by direct violence, at any point; when due to indirect force, it is generally seated within two or three inches of the external malleolus. In the former class of cases the mechanism is sufficiently obvious; in the latter it admits of some question, which is, however, not of serious importance. It may simply be said here, that it is probable that sometimes, as when the foot is brought very forcibly into abduction, so that the sole is turned outward, the tarsal bones are pushed against the malleolus so as to bend the fibula toward the tibia, and cause it to break at its weakest point. On the other hand, when the foot is violently adducted, so as to turn the sole inward, the stress upon the external lateral ligament may be such as to bow the fibula outward, and cause it to yield in the opposite direction, but at the same point—possibly a little lower down. Wagstaffe⁴ has reported two cases in which, by a twisting movement, the lower end of the fibula was split longitudinally, and a fragment detached which became rotated and wedged against the tibia so firmly that its replacement was found impossible. In one, recovery took place, though walking

¹ Am. Journal of the Med. Sciences, Aug. 1837.

² Quoted in the London Med. Record, Dec. 15, 1878, from the Gaz. Hebdomadaire, 12 Juillet.

³ Am. Journal of the Med. Sciences, Oct. 1848; from Caspar's Wochenschrift.

⁴ St. Thomas's Hospital Reports, vol. vi.

was difficult; in the other, the patient dying in thirteen hours, the condition was verified by dissection.

When the fibula gives way by extreme abduction, there may be either a rupture of the internal lateral ligament, or a tearing off of the tip of the inner malleolus—sometimes of a larger portion. When the opposite condition obtains, the malleolus may be broken off by the forcible impact of the tarsal bones against it. But these cases have already been discussed under the head of Pott's fracture.¹

The *symptoms* of fracture of the fibula are occasionally obscure. Sometimes the patient can walk, but there is always some pain, by reason of the fragments irritating the muscles, or by the slight strain brought to bear upon the broken part in the balancing motion of which walking so largely consists. Pain on pressure is always present, and swelling and ecchymosis are very apt to occur. Crepitus is generally very slight, on account of the small size of the bone, and there may be no perceptible deformity.

Keen² has pointed out, as a symptom of fracture in the lower third of this bone, a widening of the ankle, allowing of motion to a more than normal degree of the astragalus between the malleoli. This can be developed by grasping the leg above the ankle, at about the supposed seat of fracture, and then with the other hand taking hold of the astragalus itself. Malgaigne³ speaks of the widening of the inter-malleolar space, but only very casually. Fractures of the fibula are sometimes attended with other serious symptoms, especially when the upper portion of the bone is involved. Duplay⁴ has reported two such cases, in workmen caught in machinery bands and thrown against a wall. Among many other lesions, "there was found above the ordinary position of the head of the fibula a bony prominence, immovable, continuous with the tendon of the biceps. Below there was a manifest depression. . . . A few days later, a paralysis of the extensors of the foot and of the peronei muscles was noted, due doubtless to lesion of the external popliteal nerve. . . . In one case the diagnosis was verified *post mortem*; the other man left the hospital after several months, the paralysis remaining, as it still does." M. Perrin mentioned a similar case in a rider whose horse fell with him, and caught his right leg beneath him for a moment. There was "arrachement" of the head of the fibula, and very considerable diastasis of the knee-joint, with some effusion. Complete anaesthesia and paralysis of the anterior and outer part of the leg ensued. The ultimate result is not stated. Callender⁵ mentions two cases of compound fracture of the head of the fibula, in both of which amputation became necessary on account of the injury inflicted on the peroneal nerve. Barwell⁶ has recorded an instance in which fracture of the fibula was followed by the development of malignant disease. In the majority of cases, however, fractures of this bone unite favorably, and the functions of the limb are early and completely restored.

As to the *treatment* of fractures of the fibula, it may often be almost identical with that of other fractures of the bones of the leg. When there is no marked displacement, the limb may be simply kept at rest in a fracture-box, or done up with side splints, or with the Bavarian splint. If there is a strong tendency to either eversion or inversion of the foot, it may be corrected by placing a single long splint on the side toward which the foot is

¹ A very elaborate memoir on fractures of the fibula was published by Maisonneuve in the Archives Générales de Médecine, for 1840, and was republished in his Clinique Chirurgicale, tome i. Paris, 1863. The reader may consult it with advantage.

² Philadelphia Med. Times, Aug. 15, 1872.

³ Traité des Fractures, etc., tome i. p. 813.

⁴ Gaz. Méd. de Paris, 17 Avril, 1880.

⁵ St. Bartholomew's Hospital Reports, 1870.

⁶ British Med. Journal, Feb. 11, 1882.

twisted, with a well-adjusted pad or long wedge-shaped compress to push the foot outward or inward as the case may be.

FRACTURES OF THE BONES OF THE FOOT.

FRACTURES OF THE TARSAL BONES are not of very common occurrence. Those of the astragalus and calcaneum are the only ones which need be considered separately, although the other bones may be crushed, as in cases of railroad accident, or of other very great violence applied to the ankle—the fall of a heavy stone upon it, for instance. Such fractures are very apt to be compound, or to be attended with so much damage to the soft parts that amputation is inevitable.

FRACTURES OF THE ASTRAGALUS are very possibly more frequent than has been suspected, since they may easily escape recognition, and be regarded simply as severe sprains. Lonsdale¹ mentions a case in which the patient jumped from a height, alighting on his feet; there was no deformity, and the ankle was supposed to be badly sprained. Inflammation of the joint ensued, and the man died on the twelfth day, when, on dissection, the astragalus was found to be split in two or three directions. Here it seems to me that the violence was direct, although exerted through the medium of the os calcis. In a case recorded by Croly,² the fracture was due to the patient catching his foot in the stirrup as he fell from a horse; and here the force was probably indirect. Sheppard³ observed, in the dissecting-room, four specimens of fracture affecting the outer projecting edge of the groove for the tendon of the flexor longus pollicis; in three the detached piece was connected by fibrous tissue with the rest of the bone, and in one osseous union had taken place. These specimens were without history; it would seem proper to place them in the category of “sprain-fractures.” Neill⁴ has recorded an instance in which the posterior extremity of the bone was broken off, and remained united.

Displacement of the broken portion sometimes takes place. Bryant says, “I have recently removed from the inner aspect of the ankle of a man the upper half of the astragalus, that had been fractured six months previously, and displaced so as to present its upper articular facet inward.” This case had been previously supposed by the surgeon in attendance to be a fracture of the tibia and fibula. Vollmar⁵ reports an instance of fracture of the head of the astragalus, in a stout countryman who fell from a height of eight or nine feet, and presented a bony prominence in the arch of the left foot. “In front of the articulating extremity of the tibia and fibula there lay, under the raised integuments, a bony swelling, separated by a deep depression from the outer malleolus.” No hollow could be detected. Replacement was effected by extension, and in four weeks the patient was able to walk about.

MacCormac⁶ has reported a fracture of the neck of the bone, the posterior portion only being dislocated, so that the trochlear surface was directed inward and slightly backward; the inner malleolus was also detached. He refers to a similar case seen by LeGros Clark. Other cases of fracture with dislocation have been recorded by Norris⁷ and John Ashhurst, Jr.⁸ Goyder⁹

¹ Op. cit., p. 531.

² British Med. Journal, March 18, 1882.

³ Medical News, Aug. 5, 1882; from *Lancet*, July 1.

⁴ Am. Journal of the Med. Sciences, July, 1849.

⁵ Med. Times and Gazette, Jan. 27, 1855; from *Zeitschrift für Chirurgie und Geburtsk.*, 1854.

⁶ Trans. of Path. Society of London, vol. xxvi. 1875.

⁷ Am. Journal of the Med. Sciences, August, 1837.

⁸ Ibid., April, 1862.

⁹ Med. Times and Gazette, Oct. 15, 1882.

has reported a case of compound comminuted fracture of the astragalus, the malleoli being unbroken; recovery took place with a movable joint. In a case seen by Bryant,¹ a compound, complicated fracture of the head of the bone was produced by a fall from a height of some ten or twelve feet, the patient alighting on his feet. The head of the bone was removed, and the body of it restored to its normal position. Recovery ensued "with some use of the limb."

The *symptoms* of fracture of the astragalus are only obscure when there has been great violence, and swelling occurs rapidly. If there is luxation of either portion, the deformity will call attention to it, when crepitus will probably be readily detected. When the bone retains its place, there will be tenderness on pressure across it, and crepitus may be perceptible. Walking, or standing on the injured foot, will be impossible. Swelling and ecchymosis will almost certainly come on; but a patient in my wards at the Episcopal Hospital, in 1882, presented neither of these symptoms, although the line of fracture could easily be felt, and crepitus was distinct.

The *treatment* in uncomplicated cases consists simply in keeping the foot at rest and preventing or allaying inflammation. When there is luxation, it may be a question whether the fragment should be removed or left to itself, if reduction is found to be impossible. In Norris's case one fragment was excised, and the other was allowed to remain; it became carious and loose, and was removed, but the adjoining bones also became carious, and at length amputation of the leg was performed, with a fatal result. In deciding the question of operation, the patient's age, habits, and constitution must be taken into account, the prospects of a young and sound person, who has never been debilitated by excesses or hardships, being much better than those of an old, or dissipated, or broken-down subject.

When the fracture is merely compound, the surgeon should be guided by general principles.

So great a probability of permanent stiffening of the ankle exists in all these cases, that a very guarded *prognosis* should be given.

FRACTURE OF THE OS CALCIS was formerly supposed to be always the result of muscular action; but it is now known to have occurred in a number of instances by crushing. I believe that the two causes are apt to be combined, the tension of the muscles of the calf acting strongly upon the posterior portion of the bone, and exerting a leverage which must aid in overcoming the resistance of its tissue to force applied from without. On examination of a vertical, antero-posterior section of a well-developed calcaneum, it will be seen that the arrangement of the cancellous structure is principally in radiating lines from the upper articular surfaces; and that although this is admirably adapted to meet the stress ordinarily sustained, it makes the bone, crushing being once begun, very liable to be rent apart.

The accident which has most frequently given rise to this injury is a fall from a height, the patient alighting on the heel. Lawrence² saw a case in which the patient had jumped from a stage-coach, and fractured the posterior part of the bone; the fragment was drawn upward by the muscles of the calf, but, upon pulling it into place, crepitus could be readily elicited. The case did well, although the patient halted somewhat in walking.

Costance³ met with a case in which a woman, aged fifty, had her heel crushed under an overturned coach, and the fractured portion of the calca-

¹ Lancet, June 2, 1883.

² Lancet, May 29, 1830.

³ Am. Journal of the Med. Sciences, Nov. 1829; from Midland Med. and Surg. Reporter, May, 1829.

neum was drawn up "as high as five inches." It could not be replaced, and the patient, after extensive inflammation and sloughing of the soft parts, recovered with the fragment firmly adherent in its false position, and its place filled by soft "cellular substance."

South¹ says that in the Museum of St. Bartholomew's Hospital there is a specimen of horizontal fracture of the tuberosity of the calcaneum, "extending to its hinder upper joint-surface, where it is continued upwards at nearly a right angle; the fractured piece does not appear to have been actually pulled out of place." He knew nothing of its history.

He relates a fatal case of compound fracture of this bone, under his own care, and quotes another seen by Lisfranc, in which union was first fibrous, and afterwards bony.²

Sometimes both calcanea are simultaneously broken. Of this Malgaigne says that he himself saw an instance, and that one was reported by Voillemier.³ Fifield⁴ records the case of a robust German, who fell about eighteen feet, alighting on his heels; in the right foot a compound comminuted fracture of the inner side of the calcaneum was at once detected, but in the left there was simply great swelling. About a month afterward, the swelling having subsided, a plaster bandage was applied, and in less than an hour the patient died from pulmonary embolism. The left os calcis was then found to be completely smashed.

Fractures of the os calcis by muscular action have been reported by Coote,⁵ in a woman aged fifty-five, and by Anningson,⁶ in a woman aged forty-two. Stimson⁷ presented to the New York Surgical Society a specimen supposed to be of this character. The accident had occurred eight years previously, and the history of it was somewhat obscure. It appeared that the patient, a man then aged forty-five, had been knocked down by a passing wagon. "The fragment was the portion to which the tendo Achillis was attached, at least partially. It was more than an inch in length, and about three-fourths of an inch in breadth. On its outer side the periosteum was complete; on the inner side there was a growth of bone which presented the appearance of having been the result of reparative process. The fragment had united with the bone at its upper border, but was about half an inch anterior to its original position."

It seems to me that in some of these instances (the last mentioned, for example), the lesion might be properly ranked among "sprain-fractures."

Although it might seem very natural to expect that both the astragalus and the calcaneum would often suffer together, such is very rarely the case. I have, however, seen two specimens of this kind, one derived from a case of railroad injury, and the other said to have been caused by a fall on the heel. Of course in the crushes due to falls from great heights, to the passage of wheels, to entanglement in machinery, or to the fall of a heavy body upon the part, there can be no limit set to the damage likely to be done. In the Museum of the Pennsylvania Hospital⁸ there is a specimen in which "the inner malleolus is broken off, and there is a transverse but fissured fracture of the fibula two inches above the malleolus. A small piece has been broken off from the postero-inferior part of the astragalus, and an irregular trans-

¹ Translation of Chelius's Surgery, vol. i. p. 640.

² See Archives Générales de Médecine, Janvier, 1828.

³ Malgaigne gives no reference for this case, and I have not been able to find it.

⁴ Medical News, Feb. 3, 1883.

⁵ Lancet, April 28, 1866.

⁶ British Med. Journal, Jan. 26, 1878. I find also in the Index Medicus for July, 1883, the following reference: Saussol, Un cas de fracture du calcaneum par arrachement; Gaz. Hebd. des Sciences Méd. de Montpellier.

⁷ Annals of Anatomy and Surgery, July, 1883; also Medical News, Feb. 3, 1883.

⁸ Catalogue, p. 45; No. 1189.

verse fracture of the os calcis has occurred half an inch below its articulation with the astragalus." The patient had fallen from a second-story window; he refused amputation, and died of pyæmia, after erysipelas, sloughing, abscess, and secondary hemorrhage, for which the anterior tibial artery was tied.

Fracture of the lesser process, or sustentaculum tali, has been studied and described by Abel.¹ It is said to be due to falls on the sole of the foot, or to forced inversion of the foot, so that the sole looks inward. The mechanism of such an injury is obvious.

The *symptoms* of fracture of the os calcis, as may appear from what has already been said, are not always such as to lead to its easy recognition. Of course there is pain, inability to bear weight on the heel, and tenderness on pressure, while sometimes the posterior fragment is drawn upward by the muscles of the calf acting through the tendo Achillis. But Malgaigne says that he mistook the lesion, in the first case seen by him, for fracture of the fibula, and that the same error was fallen into by Voillemier as well as by Bonnet; and it is very possible that surgeons of less experience have been deceived in like manner.

Abel says that when the sustentaculum tali is detached, any attempt to stand or walk everts the foot, giving the ankle the valgus position; crepitus and abnormal mobility, although present, may be masked by the swelling; but the astragalus and tibia are displaced somewhat backward, lessening the distance between the posterior border of the inner malleolus and the tendo Achillis.

The *course* of these cases can hardly be definitely laid down. Consolidation would appear to take place only very slowly, and it is apt to be a long time before the foot becomes useful again. I think that sometimes, in the cases of caries or necrosis of the os calcis, which are met with in children, there may have been in reality an unrecognized fracture, the nutrition of the bone being irretrievably damaged. The *prognosis* must always be doubtful.

As to the *treatment*, it must consist in obviating displacement as far as possible, by keeping the foot in a proper position, attention being at first paid, of course, to keeping down inflammatory action. The best dressing for these cases is a splint along the front of the leg, extending as far as the roots of the toes, and having an obtuse angle corresponding to the instep; it may be kept in place by an ordinary roller, and afterward by a plaster or silicate bandage. The old plan of putting a slipper on the foot, and attaching it by a band to a fillet around the lower part of the thigh, is open to the grave objection that the pressure of the heel of the slipper would itself tend to push the posterior fragment out of place.

FRACTURES OF THE OTHER TARSAL BONES can hardly occur except from crushing force, and present no features which need be dwelt upon. I have never seen such a case, except when the whole ankle was smashed, and when amputation was the only resource.

FRACTURES OF THE METATARSAL BONES result only from crushing, as by heavy weights falling upon the foot, and are nearly always compound. If amputation is not demanded, the only course open to the surgeon is to allay inflammation, and to keep the foot at rest until union shall have occurred. Any displacement of the fragments must be remedied as far as possible by careful manipulation; the result is apt to be favorable. Malgaigne says: "I recently had to treat a carter, who was thrown down under his vehicle, and had the

¹ British Med. Journal, Nov. 9, 1878; from Arch. für klin. Chirurgie.

three middle metatarsal bones broken by the wheel passing over them. The anterior fragments were very greatly depressed; there was a lacerated wound on the back of the foot, and the inflammation was most intense. It was therefore impossible to remedy the displacement, and, indeed, the saving of the foot could hardly be hoped for. The patient recovered, and could plant his foot very firmly on the ground, but the great projection of the upper fragments at the back of the foot obliged him to wear a peculiarly-shaped shoe." Hammond¹ reports a case of compound comminuted fracture of the right ankle as well as of the first and second metatarsal bones of the left foot, in which the patient made a good recovery without amputation. Boyd, however, has recorded² the case of a woman, aged fifty-nine, with fracture of the four outer metatarsal bones, followed by thrombosis of the femoral artery, pulmonary embolism, and death. Such cases are not very uncommon among the broken-down subjects of hospital treatment.

FRACTURES OF THE PHALANGES OF THE TOES are very rare, except from great direct violence. Yet I have several times seen them produced by accidents to persons bathing at the seashore, without serious injury to the soft parts, the pain, crepitation, and abnormal mobility placing the character of the lesion beyond doubt. In these cases the treatment is the same as for like injuries to the phalanges of the fingers, although the small size of the parts renders the application of splints at the same time more difficult and less needful. A little bit of pasteboard may be laid along the *back* of the toe, and bound on with a strip of adhesive plaster. I have never seen permanent lameness follow a hurt of this kind.

Compound fractures of the toes, as a rule, require amputation; but there is room for the exercise of judgment in deciding this question, as nature will sometimes do more in the way of repair than might at first be thought likely or even possible. The risk of tetanus from such injuries ought never to be wholly overlooked.

OTHER INJURIES OF BONES.

Besides fractures, the bones are liable to other forms of injury concerning which the surgeon should not be ignorant.

CONTUSIONS OF BONES are not very uncommon; and although the soft parts are also bruised, and the soreness in them masks that of the bone, yet there is often perceptible for a long time a deep-seated tenderness which gives evidence that the bone has suffered. Such injuries generally affect the superficial bones, and especially the tibia, which is very apt to be hurt in the rough sports of boyhood. As a rule nature repairs the damage inflicted in this way; but occasionally the results are more serious, and inflammation may ensue; the periosteum may swell, and necrosis of the underlying bony substance, or perhaps osteitis, may follow. In rare instances, and probably only where there is a constitutional vice, the nutrition of the entire bone becomes involved, and its inflammation or its death may take place. Or, if the disorder be more localized, an abscess may form in the cancellous substance, and give rise to very troublesome symptoms.

The *treatment* of contusions of bone consists in the enforcement of rest, and the use of hot-water dressings, and perhaps leeches; but it is seldom that

¹ Trans. of the New Hampshire Medical Society, 1882, p. 105.

² Trans. of the Pathological Society of London, vol. xxxiii. 1882.

the surgeon is called upon in such cases until the more serious secondary symptoms have declared themselves, the mode of managing which will be elsewhere detailed.

INCISED WOUNDS OF BONE sometimes occur. They are most frequent as the result of accidents in saw-mills, but are occasionally met with in carpenters or wood-cutters. I once saw an old man who had fallen with his knee on the upturned edge of a scythe, which had cut clean through the patella, and laid the joint open entirely across. Gross¹ mentions the case of a man, aged thirty-nine, who had had his olecranon severed by a cut with a butcher-knife; the joint was of course laid open, and there was free bleeding. Union took place with anchylosis. In 1876, I had in my ward in the Episcopal Hospital, a man aged twenty-five, who had had a very similar injury inflicted upon him with a "drawing-knife;" the closure of the wound was impossible, and I excised the entire joint, with a fairly good result, although the motion of the parts was very limited.

Of course injuries of this kind must always be compound, and their gravity will vary according to the seat and extent of the damage inflicted on the bone, as well as the degree to which the soft parts are involved. If a limb be cut entirely through, the question will necessarily arise whether union can take place or not. Some marvellous stories are told of cases in which severed fingers have been readjusted, and with perfect success;² but my own experiments in this way have uniformly failed.

The *treatment* must be adapted to the circumstances of each case. Sometimes it will consist simply in arresting hemorrhage, closing the wound, and putting the parts at entire rest by means of splints and bandages; just as in compound fractures. Sometimes amputation will be clearly indicated; and sometimes, as in my case above mentioned, excision may be the proper course.

PUNCTURED WOUNDS OF BONE have been met with, especially in Indian warfare. These have already been considered at sufficient length in the article on Bayonet and Arrow Wounds.³

I once myself, in making an autopsy, sustained a punctured wound of the second phalanx of the middle finger; the point of a scalpel penetrated the bone, and it was seven months before the wound healed, the bone itself remaining swollen and tender.

GUNSHOT WOUNDS OF BONE have already been fully discussed in the article on injuries of that class.⁴

¹ Op cit., vol. i. p. 831.

² For one of the most extraordinary, in which the forearm is said to have been cut through all but a strip of skin, and to have healed again perfectly, see the quotation of General Hunter's case. (Med. and Surgical History of the War of the Rebellion. Part Second, Surgical Vol., p. 918, note.)

³ See Vol. II. pp. 105 *et seq.*

⁴ See Vol. II. pp. 125, 147 *et seq.*

INJURIES OF THE BACK,

INCLUDING THOSE OF THE SPINAL COLUMN, SPINAL MEMBRANES, AND SPINAL CORD.

BY

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THE region whose injuries are to be considered in this article, embraces the posterior part of the neck, chest, abdomen, and pelvis, or, in other words, the posterior part of the whole trunk excepting the head. The organs contained in this region are, (1) the spinal cord, with the spinal meninges and the roots of the spinal nerves ; (2) the vertebral column, from atlas to tip of coccyx inclusive ; and (3) the muscles both great and small which are attached to the vertebræ, together with the integuments that cover them.

The welfare of these organs is a subject of extremely great importance, inasmuch as their integrity, considering them as a unit, is essential to the very existence of man as an animal. I cannot emphasize this point in any better way than by calling attention to the fact that the vertebral column is the first portion of the skeleton to appear in man, and the centre around which all other parts of the skeleton are produced ; that the spinal cord is the first formed portion of the nervous system, and the centre to which all other parts of the nervous system are appended ; and that the chorda dorsalis of the embryo "forms the basis around which the vertebral column is developed." At first, the vertebral column is a simple cartilaginous tube which surrounds and protects the primitive trace of the nervous system in the embryo ; but, as it advances in growth and organization, it becomes divided into 33 distinct pieces constituting the vertebræ ; of which 24 are called true and 9 false. At a still later period, the false vertebræ coalesce, the upper 5 of them to form the sacrum, and the lower 4 to constitute the coccyx, the process of coalescence being completed at maturity or the termination of growth. The true vertebræ, however, do not coalesce ; but, placed one above the other, they constitute a flexible tubular column, composed of ring-shaped bones alternating with lenticular disks of firm yet elastic intervertebral substance, and bound together by broad, thin planes or bands of ligamentous tissue, many of which are also elastic. The vertebral tube is lined by the spinal dura mater, or theca vertebralis, which is continuous with the cerebral dura mater above it, and contains much cerebro-spinal fluid in which the spinal cord, attended by large plexuses of veins, hangs suspended from the base of the brain by its attachments to the pons Varolii, as it were, in a well. The cerebro-spinal or sub-arachnoidean fluid also keeps up a constant and gentle

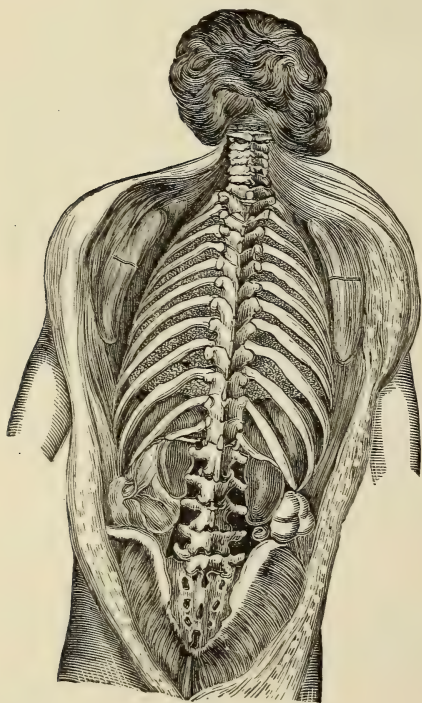
pressure upon the entire surface of the spinal cord as well as upon that of the brain, and yields with the greatest facility to the various movements of the spinal cord and spinal column, giving at the same time to the delicate structures of the cord and brain the advantages of the mechanical principles so usefully applied by Dr. Arnott in the hydrostatic bed. Thus we find that the spinal cord is protected in a truly wonderful manner from the ill effects of blows, and shocks, and pressure, by an elastic, fluid medium which everywhere surrounds and gently compresses it.

The traumatic lesions of the back naturally arrange themselves in three groups, as follows:—

- I. Injuries of the integuments and muscles, or soft parts generally.
- II. Injuries of the vertebral column.
- III. Injuries of the spinal membranes, spinal cord, and spinal nerves.

For the purposes of study and description, this classification of the traumatic lesions to which the dorsum of the trunk is exposed presents some

Fig. 851.



Posterior view of the vertebral column, ribs, etc., the integuments and muscles having been laid open and deflected from them. (Sibson's Medical Anatomy, Pl. XII.)

advantages which are quite obvious, and, therefore, I shall follow it as far as may be found serviceable. It should be borne in mind, however, that the examples which claim the surgeon's attention in practice usually illustrate at least two of these forms of injury; and that, not unfrequently, all three are simultaneously exhibited in the same patient. The symptoms and treatment of these lesions must therefore be described from general or common, as well as from specific points of view.

From most writers on surgery, injuries of the back have not received that degree of attention which their importance justly demands. This neglect may have arisen on the one hand from undervaluing the functions of the spinal cord itself, and holding it to be merely an appendage of the brain, or, on the other hand, from considering the injuries which involve the vertebral column and spinal cord, in general, to be hopeless lesions for which the surgeon's art can do no good. Nevertheless, I am fully persuaded that a considerable share of even the least promising cases are susceptible of permanent relief by judicious treatment from the surgeon; and I am supported in this view by the extremely large

proportion of recoveries which has resulted from the attempts to reduce dislocations and fractures of the vertebræ that have been recorded. For instance, thirty-four cases are mentioned in Dr. Ashhurst's tables,¹ in which reduction was attempted by various appropriate procedures, and recovery

¹ Injuries of the Spine, pp. 71–121. Philadelphia, 1867.

ensued in all but four. In many, the successful issue of the efforts at reduction was indicated by an audible sound or a "snap." In several the paralysis was instantly relieved.

I. INJURIES OF THE SOFT PARTS.

INCISED AND PUNCTURED FLESH-WOUNDS OF THE BACK.

Wounds are inflicted with cutting and puncturing instruments in the back part of the neck, chest, abdomen, and pelvis, by accidents, by criminal design, and in war, with so much frequency as to require at least some mention of them in this place. For instance, "punctured and incised flesh-wounds of the back were exemplified by fifty-six instances [during our late civil war], of which twenty-one were cases of bayonet-stabs, thirteen of sabre-cuts, and twenty-two of punctures and incisions by sundry weapons. None of these cases are recorded as terminating fatally, though in six the result has not been ascertained; forty-five were sent to duty, and five were discharged. Several of these cases were examples of severe though not dangerous sword-wounds."¹ Of the thirteen examples of sabre-cuts, twelve were received in action. The bayonet-stabs, however, appear to have been inflicted almost entirely by sentries, or by provost-guards, or in brawls, or through accidents. But one example is specified as a wound received in action, and this wound may not have been inflicted by the enemy. Sabre-wounds of the back are seldom mentioned in the literature of surgery. No instance is related by either Guthrie or Hennen. Bilguer, however, gives an instance that occurred in the Seven Years War (1756-63): A cavalry soldier, J. R., while retreating and leaning over his horse's neck, received two cuts in the lumbar region.² He appears to have recovered. But Morgagni records an autopsy in a case of sabre-thrust in the back.³

Incised wounds which sever to a considerable extent the fasciculi of the trapezius, latissimus dorsi, or rhomboid muscles, are apt to gape widely open. In treating such wounds, it is necessary, after stanching the bleeding and removing the coagula and all other foreign bodies, to introduce at the outset sutures of carbolized silk, which are antiseptic, or of silver or iron wire, which are also antiseptic *per se*, in sufficient number and at sufficiently short intervals, and at a sufficient depth, to bring the divided parts into complete apposition, where they should be allowed to remain until the union is complete. Under this plan of treatment, with quietude, the results of flesh-wounds of the back (incised) are almost always very favorable. But if no sutures be introduced, and the gaping wound be allowed to fill up and heal by granulation, some considerable time may be required before recovery takes place.

INCISED OR PUNCTURED FLESH-WOUNDS OF THE BACK OF THE NECK.—If these penetrate deeply, they may open the vertebral or the occipital artery, and thus cause a hemorrhage which, if not restrained, will speedily prove fatal, on the one hand; or, unless promptly treated in a radical manner, will give rise to a traumatic aneurism of an almost equally fatal character, on the

¹ Med. and Surg. History of the War of the Rebellion, Second Surgical Vol. p. 429.

² Chirurg. Wahrnehmungen, S. 493. Berlin, 1763.

³ De Sed. et Causis Morb., Ep. liii. p. 270. 1765.

other. Hennen, indeed, remarks that "simple incised wounds on the back of the neck, although sometimes penetrating to a great depth, and even uncovering the vertebral arteries, are not beyond the reach of simple bandage, and retention by adhesive strips and sutures; feebleness of the extremities, particularly the lower, is a more frequent source of complaint, in these cases, than hemorrhage."¹ Nevertheless, there are many cases on record in which stabs in the nape of the neck opened one of the vertebral arteries, and thus gave rise to most disastrous consequences. Dr. Kocher, of Berne, relates an excellent example of this sort, in *Langenbeck's Archives*;² and he remarks that it is the twenty-first recorded case of traumatic aneurism of the vertebral artery. In twelve of these twenty-one cases, the wounds were stabs. In ten cases the result was fatal before any pulsating swelling appeared. In eleven cases where life was prolonged until there was pulsating swelling, but two recoveries occurred.³ Thus it appears that flesh-wounds in the nape of the neck which involve either of the vertebral arteries are exceedingly dangerous to life, that the ratio of mortality for this lesion has, hitherto, exceeded 90 per cent., inasmuch as nineteen out of twenty-one recorded cases have proved fatal, and that the surgical treatment of this form of injury is a subject of very great importance to practitioners as well as to patients. It may be useful to state in this connection the chief causes of this striking want of success. In eleven cases, the carotid artery was tied, through error in diagnosis, and this operation probably rendered the evil greater, by increasing the blood-pressure in the wounded vertebral artery; indeed, in two of the cases thus operated on, the patient died of violent hemorrhage from the seat of injury; and in three other cases belonging to the same category, death occurred from bursting of the aneurism. In five instances, the ligation of the carotid was followed by paralysis that proved fatal. Lücke, in a case where the aneurismal swelling increased rapidly after ligating the carotid, injected into the sac chloride of iron, and also applied plugs saturated with the perchloride; the patient, however, died with symptoms of paralysis. Maisonneuve, in a case of gunshot wound, tied both the vertebral and the inferior thyroid arteries, and extracted the missile. The bleeding was arrested, but death ensued from the infiltration of pus into the spinal canal, and consequent inflammation. One patient died of septicæmia following suppuration of the connective tissue of the neck. In several cases there was hemorrhage that resulted in death.⁴ But, as stated above, an error in diagnosis, a mistaking of the wounded artery for a branch of the carotid with consequent ligation of that vessel, was by far the most frequent cause of failure in treating these cases; and, inasmuch as such errors in diagnosis are avoidable when the likelihood of their occurrence is borne in mind by surgeons, there is good reason to hope that much better results will hereafter be achieved in treating flesh-wounds in the nape of the neck which involve either of the vertebral arteries.

But flesh-wounds of the posterior cervical region may lay open other arteries of importance as well as the vertebral, for instance, the *profunda cervicis*, a branch of the subclavian, the *arteria princeps cervicis*, a branch of the occipital which inosculates freely with the *profunda cervicis*, and even the *occipital artery* itself. In Dr. Kocher's case it was, at first, uncertain whether the vertebral or the deep cervical was injured; but the occurrence of hemorrhage on removing the dressing, and the result obtained by introducing a finger into the wound as far as the transverse processes of the vertebræ,

¹ Principles of Military Surgery, p. 285, Am. ed.

² Archiv für klin. Chirurg., Bd. xiii. S. 867.

³ New Sydenham Soc. Bien. Retrospect, 1871-72, pp. 202, 203.

⁴ Ibid., p. 204.

whereby the blood was perceived to issue from a point between two transverse processes, apparently the fifth and sixth, soon made the diagnosis clear. In Möbus's case, which is mentioned by Dr. Kocher as the only instance of traumatic aneurism of the vertebral artery, besides his own, which eventuated in recovery, there was a pulsating tumor below the occipital bone on the right side. It might have arisen from a wound of the occipital just as well as from a wound of the vertebral artery; but the pulsation was not arrested by compressing the occipital artery, and the tumefaction was not lessened by compressing the carotid, wherefore the vertebral was inferred to be the seat of the lesion.¹

Flesh-wounds in the posterior cervical region that also lay open one of the occipital arteries, have proved almost as deadly as similar wounds that lay open the vertebral arteries, mentioned above. The principal reason for these untoward results has been that surgeons, owing to difficulties real or fancied that they have met with in trying to tie the wounded occipital artery in the wound itself, have resorted to untrustworthy expedients, instead of persevering as they should have done until success had crowned their efforts to ligature the bleeding vessel on each side of the aperture in its walls. From the employment of temporizing measures, it has resulted that the hemorrhage, although restrained for a brief period, has burst forth afresh from day to day or from time to time, until, finally, the patient has perished miserably from anæmic exhaustion, or, in other words, has slowly bled to death, and that, too, beneath the surgeon's very eyes. The following example well illustrates this subject.

A young man, aged 22,² received in an affray a stab-wound in the neck, two inches in length by one inch in depth, behind the left ear, and about two inches distant from the auditory meatus. Half an hour afterward the medical man found him pale and faint from loss of blood. The hemorrhage still continued in feeble jets; but pressure applied at the bottom of the wound with a finger readily suppressed it. On failing to grasp the wounded artery with forceps, it was resolved to treat the hemorrhage by compression. Thereupon the wound itself was stuffed with lint, and the lips thereof were drawn together over it, and secured in apposition with interrupted sutures. This proceeding controlled the hemorrhage for five days, when slight bleeding recurred. On the sixth day there was more hemorrhage. On removing the dressing the bleeding was very profuse, and could not be entirely suppressed by pressure with a finger in the wound. The left common carotid artery was then tied, and the bleeding ceased. Three days afterward, however, a slight hemorrhage appeared in the original wound, and in twelve days more hemorrhage again occurred from the same wound, on opening which, the blood was found to issue from the occipital artery, at a point behind the mastoid process. Manual compression was now resorted to, but two days subsequently the patient died, having survived the wound twenty-three days, and the deligation of the common carotid artery seventeen days. An *autopsy*, made ten hours after death, showed that the knife had penetrated between the mastoid process of the left temporal bone and the transverse process of the atlas, and had opened the occipital artery in the occipital groove. The occlusion of the carotid was perfect. The brain was not diseased. Death appears to have resulted from anæmic convulsions and anæmic exhaustion, that were caused by the regurgitant hemorrhages from the wounded artery.

Deligation of the common carotid in this case failed to control the hemorrhage, because it did not control the circulation of blood in the wounded part of the occipital artery; and it did not control the circulation because of the great freedom with which the terminal branches of the two occipital arteries inosculate with each other across the median line, and with branches of the temporal and posterior auricular arteries in the scalp, and likewise by means

¹ *Ibid.*, p. 204.

² *American Medical Times*, May 18, 1861, p. 320.

of the arteria princeps cervicis with the profunda cervicis in the deep part of the neck. In consequence of the great freedom of this arterial intercommunication, the closure of the common carotid was not attended with such a stoppage of the blood-flow in the wounded part of the occipital artery as is requisite for the formation of blood-clots which can permanently close the aperture in the arterial tunics, and thus effectually restrain the hemorrhage. Wherefore it happened, that, as soon as the blood-pressure rose again after the operation of tying the common carotid was performed, the occluding clots were driven out of the aperture in the arterial tunics, and the bleeding started afresh from the distal as well as from the proximal portion of the wounded artery. Thus it is shown that the only procedure which might have saved this patient would have consisted in tying the injured artery in the wound itself with two ligatures, one of them being applied on each side of the aperture in its walls, so as to prevent the regurgitant as well as the direct hemorrhage; and had this operation been promptly performed by the physician who first saw the patient, there is good reason to believe that he would have promptly recovered.

In *treating* flesh-wounds of the posterior cervical region which open any bloodvessel of importance, the first and the most important indication consists in suppressing the hemorrhage, without delay, by applying two ligatures to the injured vessel in the wound itself, placing one of them on each side of the bleeding aperture in its walls. To fulfil this indication it will be necessary to bring the bleeding orifice or ends of the vessel distinctly into view; and, to this end, whenever the wound is not large enough to allow the bleeding point or points to be seen and secured with ligatures, the surgeon, having first introduced a finger of his left hand into the wound, and placed the tip of it on the spot whence the blood issues from the vessel, so as to control the hemorrhage for the time being, should enlarge the wound with a bistoury, held in his right hand, until the source of bleeding is fairly brought into view, bearing in mind, of course, the anatomical structure of the parts involved, and carefully avoiding all nerves and other organs of importance. Then he must ligature the distal as well as the proximal end of the wounded artery, in order to repress the regurgitant as well as the direct hemorrhage; and, in cases where the artery is not already completely divided, it is well to finish the operation by completing the division of the arterial tube with a bistoury, applied midway between the two ligatures, so that the ends of the vessel may be allowed to retract and contract. However great the obstacles in such cases may be, the surgeon must persevere until he has overcome them, and has suppressed the hemorrhage in this radical manner; otherwise he will pretty certainly be annoyed and mortified by seeing his patient slowly bleed to death, in spite of all that he has done, as happened in the case just related.

The application of a distal as well as a proximal ligature to the vertebral artery, when wounded, is quite as necessary as it is in the case of the occipital, or the profunda cervicis; for the two vertebrae unite together to form the basilar artery, and, therefore, the blood is capable of regurgitating in either of them with great force. But a large part of the course of each vertebral artery is occupied by its passage through the foramina in the transverse processes of the upper six cervical vertebrae, together with the spaces intervening between the transverse processes of these six cervical vertebrae. Now, the vertebral artery is not unfrequently wounded in this part of its course, and here, because of its anatomical relations, ligatures cannot be applied. What, then, is to be done in such cases in order to stanch the hemorrhage? Happily this problem has been solved by Dr. Kocher, who has presented us with a successful example, already several times referred to above. His plan of treatment I shall now proceed to describe:—

The patient was a man, aged 48. He had a stab-wound in the nape of his neck, the hemorrhage from which had been restrained to a considerable extent by plugs soaked in styptic solutions, etc. On removing the dressings, there was seen at the level of the fifth and sixth cervical vertebræ, about an inch to the left of the spine, a roundish wound about two-thirds of an inch in diameter. On removing the coagulum which lay in the wound, some dark blood escaped; and, on withdrawing the finger used for exploration, a rather violent hemorrhage of bright red blood followed. The wound was then laid open to the extent of about three inches, and a large quantity of coagulum was removed by the finger. Thus a cavity was found, having the size of a small apple, and at the bottom the posterior surfaces of the left articulating processes were felt, and, more distinctly, the transverse processes of the vertebræ. A transverse incision was now made, an inch and a half in the anterior, and half an inch in the posterior direction; and the blood was then seen to issue from a point between the transverse processes of two vertebræ, apparently the fifth and sixth cervical. The blood escaped from the distal as well as from the proximal portion of the artery; and the hemorrhage was arrested by pressing against the transverse processes, either from above or from below. No ligatures could be applied to the wounded artery. A plug of charpie of the size of a pea, soaked in a solution of the perchloride of iron, was therefore introduced between the transverse processes, and left there. It stopped the bleeding. The external wound was closed with sutures, and dressed antiseptically. The head was kept fixed by a stiff collar. On the fourth day after the operation, the plug in the deep part of the wound was removed, partly by means of a stream of water, partly by forceps; no bleeding followed. The patient was discharged cured, a little more than five weeks after the operation.¹

In similar cases, the wounded vertebral artery might be successfully plugged by pressing into its lumen one or more cones, made out of fresh animal tendons (readily procurable at almost any butcher's stall), having the diameter of a pea, and having been smeared over with a strong solution of ferric perchloride, instead of a wad of charpie. The animal-tissue plugs could be allowed to remain *in situ*, where ultimately they would undergo absorption and be replaced by new connective tissue. Both ends of the wounded vertebral artery must, in general, be plugged.

When the muscular and connective tissues of the neck are extensively infiltrated with blood, as soon as the wounded artery has been securely ligatured or plugged, and the coagula have been removed, the wound itself should be thoroughly cleansed with a two-per-cent. solution of carbolic acid. Externally, the wound having been closed by interrupted sutures should be dressed antiseptically, and should have left in it an adequate drainage tube, reaching to the bottom. Thus, septicæmia, which is very apt to appear and prove fatal in such cases, may be avoided.

Hennen calls attention to the fact that in wounds of the back, "sinuses are also very apt to form along the spine, and they often prove very troublesome; I would never trust [he justly observes] to pressure in these cases, but would make a free though cautious incision. These incisions are sometimes rendered very necessary by the lodgment of balls, pieces of cloth, etc."²

These sinuses and abscesses along the spine and in the muscles of the back having been freely opened, their contents discharged, and all foreign bodies removed, they should be thoroughly washed out by injecting a two-per-cent. solution of carbolic acid, and should be treated by securing complete drainage with velvet-eyed tubes of rubber, deeply inserted, as well as by applying antiseptic dressings externally.

To sum up the treatment of flesh-wounds which also lay open important arteries in the posterior cervical region:—

¹ New Sydenham Soc. Bien. Retrospect, 1871-2, pp. 202, 203.

² Op. cit., p. 350.

(1) The diagnosis as to what vessel is injured must be made by exploring the wound itself with a finger, ascertaining by the tactile sense the point whence the blood issues, and determining by the same means its anatomical relations.

(2) The bleeding vessel must be brought into view by enlarging the wound without delay; and it must then be tied at the place of injury with two ligatures, one of them being applied on each side of the aperture in its walls, or to each end of the artery if it be severed. The artery should be divided midway between the two ligatures, for the purpose of allowing its ends to retract and contract, in all cases where it has not been severed by the original wound.

(3) When one of the vertebral arteries is wounded in that part of its course which lies in the canal formed by the foramina in the transverse processes of the six upper cervical vertebræ, the hemorrhage must be restrained by plugging the injured artery in the manner described above, because in this situation ligatures cannot be applied.

(4) These wounds should be thoroughly cleansed with antiseptic lotions. Their lips should then be drawn together, and held in apposition, by means of interrupted sutures. Should the occurrence of deep-seated suppuration be probable, adequate drainage tubes should be inserted. Antiseptic dressings should be employed externally.

(5) Inasmuch as there is great flexibility in the neck, fixing the head by means of a stiff collar, so as to secure quietude in the cervical muscles, will considerably expedite the recovery, and diminish the liability to secondary hemorrhage; and it should therefore always be employed in these cases.

I have considered the flesh-wounds in the posterior cervical region which involve also the vertebral, the occipital, the deep cervical, or other arteries, at considerable length, because of the enormously high rate of mortality which has attended the reported examples of these lesions, amounting to fully 90 per cent.; and I believe that the principles of treatment enunciated above, when generally applied in practice, will greatly lessen this awful ratio, and correspondingly increase the chances of recovery from these exceedingly troublesome forms of injury.

INCISED OR PUNCTURED FLESH-WOUNDS OF THE BACK, RECEIVED BETWEEN THE SHOULDER-BLADES.—These wounds not unfrequently penetrate the thoracic cavity. The following example, taken from my note-book, affords a good illustration of this point:—

A government teamster, middle-aged and robust, was stabbed in the back, at Washington, August 15, 1861, in a brawl. He received a cut about three inches in length, extending up and down, between the base of the left scapula and the spinous processes of the dorsal vertebræ, but rather nearer to the scapula than to the spinous processes. The muscles were divided down to the ribs, and the left pleural cavity was freely opened, so that air in large quantity was drawn into and expelled from that cavity by each respiratory movement. He was at once taken to the E Street Infirmary. When admitted, he was much prostrated from shock, and had considerable dyspnœa. As soon as the bleeding was completely stopped, which required a little time, the lips of the wound were brought into apposition and retained by three points of interrupted suture, and by strips of adhesive plaster.

August 20.—Most of the wound has united by the "first intention," and he has convalesced thus far without even one unfavorable symptom. There has been no pain in the side nor any other sign of pleurisy. Subsequently he did well in every respect, and soon left the hospital entirely cured.

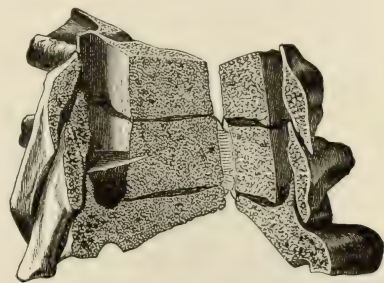
It was observed in this case that the wound gaped considerably; and, therefore, each of the three points of interrupted suture was passed through the rhomboid muscle, as well as through the exterior plane of muscles and the skin. Thus the edges of the wound were securely held in close apposition, and a speedy recovery was obtained.

Incised wounds of the back not unfrequently perforate the theca vertebralis, and lay open the spinal canal. The occurrence of this lesion is attended with the escape of cerebro-spinal fluid; and, in cases where the spinal cord and spinal nerves had not been injured, the escape of this fluid through the wound would alone indicate the nature of the lesion.

Professor Agnew has pointed out "the exposed condition of the contents of the spinal canal" in the posterior region of the neck," and states that "it is due to the horizontal direction of the spinous processes, by which vulnerable spaces are left between." Professor Agnew also says: "The popular notion that posterior cervical wounds are followed by sexual impotence must be founded on cases of injury to the cord or its membranes. The testimony of Legouest, who had abundant opportunities for observation on this point during the conflicts of the French with the Turks, gives no countenance to this opinion."¹

But incised wounds in the posterior region of the chest also not unfrequently penetrate the spinal canal, and cause paraplegia by injuring the spinal cord, notwithstanding that the spinous processes of the dorsal vertebræ do not extend in a horizontal direction. The following example occurred during the late civil war:—

Private George S., Co. B, 15th New York Engineers, was admitted to Armory Square Hospital, Washington, April 22, 1863, having been stabbed with a knife in the back at Falmouth, Va., on the 20th, that is, two days before. He was completely paraplegic; the urine had to be drawn off by a catheter; and nothing but croton oil, in three drop doses, succeeded in moving his bowels, three days after admission; two days after that, involuntary defecation and micturition set in. Sphacelus of all the projecting points on the lower part of his body soon followed, and proceeded rapidly until it nearly exposed the spines of the sacrum. On May 10, chills came on, and recurred daily. Death ensued on May 26, from exhaustion. The *autopsy* showed that the knife had penetrated the fifth dorsal vertebra. The fourth, fifth, and a part of the sixth dorsal vertebræ were removed and sawn through longitudinally to exhibit the knife-blade, which appears to have been broken off, and to have remained fixed in the body of the fifth dorsal vertebra ever since the injury was inflicted. The specimen is preserved in the Army Medical Museum; and it is represented by the accompanying wood-cut. (Fig. 852.)²



The fourth, fifth, and a part of the sixth dorsal vertebræ, sawn open to exhibit the blade of a knife which had broken off after traversing the spinal canal and spinal cord. (Spec. 1160, A. M. M.)

Another instance of incised wound of the back, involving the vertebral column, was likewise recorded during the late civil war:—

Private Wm. D. Cook, company D, 6th Tennessee Cavalry, aged 25, was admitted to Overton Hospital, Memphis, Tenn., November 25, 1864, with an incised wound of the spine inflicted on the 10th, that is, fifteen days before, with a knife. Simple dressings were applied. The patient was returned to duty on December 15.³

¹ Principles and Practice of Surgery, vol. i. p. 321.

² Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 425.

³ Ibid., p. 45.

In this case it does not appear that the spinal cord or spinal nerves sustained any injury. No other examples belonging to this category were reported during the late civil war.

Dr. Meryon¹ presents a very instructive case of incised wound in the back, penetrating the vertebral column and injuring the spinal cord, in which complete recovery took place.

A boy, aged 15, received a wound from a cutting instrument in the back, which penetrated between the tenth and eleventh dorsal vertebræ, and probably divided the right half of the spinal marrow. There was complete paralysis of motion, and incomplete loss of sensibility in the right thigh and leg. The patient made a good recovery, and at the end of two months was able to walk four or five miles. A prominent symptom in this case, which has often been observed in similar cases, was the escape of a quantity of cerebro-spinal fluid from the wound during the first twelve days after the injury.

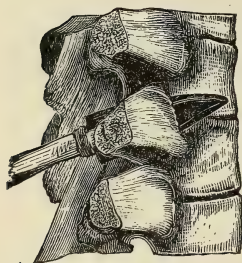
Dr. Schwandner reports a somewhat similar instance, in which a punctured wound of the back injured the spinal cord between the second and third dorsal vertebræ. Paralysis of the right foot and leg, shortness of breathing, together with involuntary defecation and micturition, were present. The foot remained partially paralyzed; but, in other respects, the recovery was complete.²

Under the head of punctured wounds of the back, the following examples are also embraced:—

Hennen reports that, "in a sergeant of the Enniskillen Dragoons, wounded at Waterloo, a piece of the shaft of a Polish lance stuck fast between the spinous processes of the last two dorsal vertebræ, completely paralyzing him until it was removed."³

In arrow-wounds of the back the missile sometimes penetrates the vertebral column, as happened in a case the specimen from which is represented

Fig. 853.



Showing an arrow-head, impacted in the right transverse process of the fourth dorsal vertebra.—(Spec. 5673, Sect. I. A. M. M.)

by the accompanying wood-cut (Fig. 853). This specimen was obtained from the body of a white man killed by Indians (by an arrow-wound of the heart, etc.) in 1869, at an outpost near Fort Concho, Texas, and was sent to the Army Medical Museum. It consists of the fourth and fifth, together with portions of the third and sixth, dorsal vertebræ. An arrow-head is shown impacted in the right transverse process of the fourth dorsal vertebra and posterior extremity of the rib. The spinal canal was not opened by the missile.⁴ "The force with which arrows are projected by the Indians is so great that it has been estimated that the initial velocity of the missile nearly equals that of a musket ball. At a short distance an arrow will perforate the larger bones without comminuting them, or causing a slight fissure only."⁵

One example of an incised flesh-wound of the *sacral region* has come under my own observation. The patient was a lad, aged about 18, who was cut by the lower angle of an axe that accidentally fell from his right shoulder, upon which he was carrying it as he walked, and struck against the sacrum, a little to the right of the median line. The wound was about two and a

¹ Researches on the Various Forms of Paralysis, p. 69. London, 1864. Quoted from L'Union Médicale, 1860, p. 552.

² New Sydenham Soc. Year-Book, 1859, p. 429.

⁴ Circular No. 3, S. G. O., August 17, 1871, p. 153.

³ Op. cit. p. 350.

⁵ Ibid., p. 160.

half inches in length, extending somewhat obliquely from above downward, and penetrated to the bone, which was also slightly cut by the edge of the axe. There was considerable hemorrhage, but no ligatures were required. The bleeding having been stanch'd, and the coagulum entirely removed, the edges of the wound were brought into apposition, and fixed without difficulty by strips of adhesive plaster. The wound united throughout by the first intention, but the patient complained for a long time of having pain and soreness in the sacrum beneath the cicatrix. These symptoms, however, ultimately disappeared without the occurrence of suppuration or the discharge of any pieces of bone.

CONTUSIONS AND CONTUSED WOUNDS OF THE BACK.

The skin on the dorsal region of the human subject is so thick and strong that it will stand a great deal of hard usage without breaking. There is, however, a considerable liability to the occurrence of contusions and contused wounds in the posterior cervical, dorsal, lumbar, and sacral regions, from railway accidents, from falls, from blows with blunt instruments, and from the impact of falling bodies or of the missiles of war. The following examples are in point:—

Contusion of the Sacral Region from a Railway Accident.—Private John Holden, Co. C, 29th Infantry, aged 23; was injured at Keswick, Va., September 28, 1868. He was admitted to the post hospital at Camp Schofield, Lynchburg, on the next day, and stated that, while riding on the top of a box car, and seeing the next car in front rolling over an embankment, he jumped off, but, being unable to escape, was struck on the back by the car as it rolled over. He complained of intense pain over the sacrum, extending between the anterior superior spinous process and the right tuber ischii. The parts over the sacrum were exceedingly tender under pressure, the slightest motion or touch causing him to scream with pain. No crepitus could be elicited. He could flex the leg on the thigh without pain, but was unable to flex the thigh on the pelvis. The injured part was much ecchymosed; and he had a dull, moving, continuous pain, extending across the whole front of the pelvis. Anodynes, with a nourishing diet, were administered. The patient made a good recovery, and was returned to duty on November 26.¹

Contusions of the Dorso-Lumbar Region from Blows with the Butt-end of a Musket.—Private Thomas Carroll, Battery L, 1st Artillery, aged 23, presented himself at surgeon's call October 5, 1867, at Fort Porter, N. Y., stating that, some time during the previous night, he had been struck in the back with the butt-end of a musket in the hands of a sentinel. The blow had knocked him down, whereupon he had been struck twice in the splenic region with the same weapon. On examination, a slight wound, such as might have been made by the percussion hammer of a musket, was found about an inch and a half to the left of the articulation of the twelfth rib with the twelfth dorsal vertebra. About two inches lower, at the same distance from the second lumbar vertebra, another wound of the same character was found. The man was treated in the post hospital at Fort Porter, until Oct. 21, when he was returned to duty entirely cured.²

Contusion of the Back caused by a Fall.—August Burtz, artificer of Co. H, 2d Infantry, aged 38, was admitted to the hospital at Taylor Barracks, Ky., November 7, 1868, having fallen from a ladder to the floor, a distance of fourteen feet. He complained of pain in the bowels, and inability to pass water, and suffered considerably from shock. A stimulant and an anodyne were administered. On the 8th he was improved. On the 10th he was taken with intermittent fever, which yielded to quinine and iron. He speedily recovered, and was returned to duty on the 15th.³

¹ Circular No. 3, S. G. O., August 17, 1871, p. 106.

² *Ibid.*, p. 106.

³ *Ibid.*, p. 106.

These examples well illustrate the usual course of ordinary contusions of the back, when they are treated with quietude, nourishing food, and anodynes, as required. But, these excellent results are not always so easily, nor so speedily obtained, by even the best-devised plans of treatment; as the following case, in which a severe bruise of the sacral region was followed by periostitis and sub-periosteal abscess, will serve to show:—

Private Thomas Morgan, Co. A, 42d Infantry, aged 34, was admitted to the hospital at Fort Niagara, N. Y., October 2, 1867, the wheel of a loaded cart having passed over his pelvis on the previous day. There was swelling, together with extensive ecchymosis, of the integuments over the upper part of the sacrum, and he complained much of pain. He also was not able to walk. A stimulating lotion was applied to the contused part, and anodynes were administered. A tumor, which formed in the injured part, was several times evacuated by incisions. The patient likewise suffered from chills and fever. By November, his general health had improved under expectant treatment; but the wound of operation was still open. On December 6, he was permitted to do light duty. On the 27th he was returned to hospital; the wound was swollen, inflamed, and freely discharged dark purulent matter. The swelling having subsided by January 13, 1868, and the condition of the wound remaining unchanged, an incision three inches long was made down to the diseased structure, which was found to be a hard cartilaginous growth containing osseous deposits, between which and the periosteum the purulent matter had been lodged, and had been escaping therefrom by means of an opening. On dissecting out this morbid growth, and touching the walls of the residual cavity with nitrate of silver, the wound was closed with adhesive strips, and a compress was applied. But little suppuration followed; and, on the 28th, the wound being nearly healed, the patient was returned to duty.¹

Not unfrequently, however, the degree of injury is much more considerable than it was in either of the above-mentioned cases, and the process of reparation then consumes much time, on the one hand, or a fatal result ensues from sloughing of the injured part, from long protracted suppuration, or from septicæmia, on the other. One of these conditions is very apt to obtain in cases where the injury is inflicted by the missiles of war. A striking example of violent contusion of the soft parts in the dorso-lumbar region came under my observation at Stanton Military Hospital, during the late civil war.

The patient, who was a soldier, tall, broad-shouldered, and very strongly built, aged about 30, was injured by the explosion of a shell while lying on the ground face downwards, probably in line of battle. He thought that the butt-end of a shell had struck his back. On examination, there was found centrally situated in the dorso-lumbar region, a circular portion of the skin fully six inches in diameter, that was very much discolored by ecchymosis, although wholly unbroken, was raised up considerably above the surrounding surface, and exhibited fluctuation distinctly when the fingers were applied to it, because a copious extravasation of blood into the subcutaneous connective tissue had taken place. So there was in reality present an immense hæmatoma, having a flattened shape, and a diameter of at least six inches, the product of an exceedingly powerful blow on the middle of the back, which did not break the skin. The treatment consisted of quietude, a nourishing diet, the administration of anodynes, and the application of camphorated oil to the injured part. But, notwithstanding the care taken to prevent it, the integuments sloughed off throughout the whole of the circular space above mentioned, and the extravasated blood was completely discharged thereby, leaving, however, a healthy granulating surface fully six inches in diameter. Simple dressings with unguentum resinæ were applied, the supporting plan of internal treatment was continued, and the sore rapidly cicatrized. When his recovery was far advanced, the patient was transferred to a northern hospital, and thus passed out of my sight.

¹ Ibid., p. 108.

Concerning the occurrence of contusions of the back in the Crimean War, Staff-surgeon T. P. Matthews writes: "Very many wounds of this region were inflicted by shell, and the position uniformly adopted as safest while awaiting a shell explosion, viz., lying on the face, accounts for this. The contusions were often large and serious, and, when not immediately fatal, enormous masses of tissue often sloughed out, and the patient died exhausted and worn out by profuse suppuration, or, if recovery took place, the wound healed by the granulating process."¹

Hennen reports the following case of contusion of the back from a spent cannon-ball, which proved fatal:—

A gallant artillery officer received a contusion from a spent round-shot, at the battle of Vittoria, which struck him exactly between the scapulæ, barely leaving a discoloration of the skin, and a slight stiffness of the parts. To this he was advised to apply cloths wet in a saturnine solution, which he gradually increased in strength. He derived, however, very little benefit from this mode of treatment; the stiffness still continued, the discoloration increased, and he was advised by some casual visitor to apply a blister to the part. In an evil hour this advice was acceded to; and in a very few days the whole back, down to the lumbar region, was covered with a dusky erysipelatous inflammation. Sloughing abscesses speedily formed in the injured part, which were attended with a horribly offensive discharge; and, in a few weeks, death closed the scene.²

Hennen also justly remarks concerning this case: "To apply strong saturnine solutions, or leeches, to a part under these circumstances, is extremely injurious, because they tend to depress still more the powers of life; to overstimulate by blisters is equally destructive of the vitality of the parts, and more hurtful to the general constitution."³

As to the *treatment* of contusions of the back when caused by the explosion of shells or the impact of spent cannon-balls, there are three points to be most carefully attended to in managing these cases: *First*, the lotions applied as discutients should not be purely sedative, nor powerfully exciting, but of a mildly stimulating nature. *Secondly*, when effusions of blood (hæmatomata), or formations of purulent matter (abscesses), are clearly diagnosed, and require removal, they should be evacuated through small valvular apertures, and the admission of air should be avoided, as far as possible. *Thirdly*, the dressings should be antiseptic in their nature; for instance, a two-per-cent. solution of carbolic acid in water already containing ten per cent. of alcohol, or a four-per-cent. solution of carbolic acid in camphorated oil, should constitute an important element of the dressings. Furthermore, a nourishing diet should generally be allowed in these cases, and, not unfrequently, alcoholic stimulants also.

LACERATED FLESH-WOUNDS OF THE BACK.

Hippocrates, in the twenty-third section of his work on wounds, treats briefly of wounds of the back, and directs attention almost exclusively to those inflicted by the lash, that is, to certain forms of lacerated wound occurring in this region. For the cure of these injuries he recommends the application, at first, of cataplasms, consisting of boiled onions or of squills; and, subsequently, of an ointment made of goat's fat or fresh lard, together with oil, resin, and salt of copper—a preparation upon the whole not unlike the *ceratum resinæ* of the modern pharmacopœia (a most useful dressing for slowly

¹ Med. and Surg. History of the British Army in the Crimea, vol. ii. p. 336.

² Op. cit., pp. 92, 93.

³ Ibid., p. 93.

healing and indolent sores), to which a small percentage of cupric sulphate or acetate has also been added.

But some of the most impressive instances of lacerated flesh-wounds of the back, on record, have resulted from explosions of shells. The next two examples are reported in the Medical and Surgical History of the War of the Rebellion, and they will serve to illustrate this topic in an excellent manner:—

A soldier, aged 19, was wounded July 13, 1864, in the entrenched lines before Petersburg, by a large shell-fragment, which tore away the dorsal integuments over a space measuring at least six by eight inches, and severely lacerated the subjacent muscles, but without injuring the ribs or the vertebral column. There was no bleeding, and the shock was comparatively slight. The lesion is well shown by the accompanying wood-cut (Fig. 854). The patient, after partaking of restoratives, and having the raw surface of his wound covered up by a water dressing, was taken to the Depot Field Hospital, at City Point. While here, only such tissues sloughed as were utterly disorganized by the projectile, and the large surface that was exposed soon granulated kindly, so that, after a month, the patient was in a condition to be transferred northward; and, on August 15, he entered the Whitehall Hospital, at Bristol, Pa. The cicatrization progressed rapidly. On September 12, he was furloughed, and on October 4, he

Fig. 854.



Showing a shell-wound of the back, 6 by 8 inches in extent. Recovery ensued.

was readmitted, being fairly convalescent. On January 23, 1865, he was sent for modified duty in the Veteran Reserve Corps. On June 24, he was mustered out of the service. No application for a pension has been made by this man or his heirs.¹

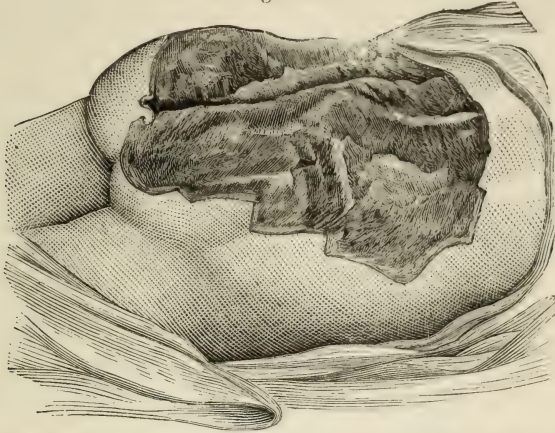
Inasmuch as the men were often ordered to lie on the ground, face downward, while under artillery-fire, huge lacerations of the back were not infrequently observed by our military surgeons during the late civil war. Commonly, however, these wounds rapidly healed, as happened in the case just related. But, sometimes, the process of reparation was very slow after such lacerations. Other conditions being equal, flesh-wounds in the flanks and buttocks were found to be more serious than those in the upper dorsal region. In cases where large masses of muscular tissue were torn away, the cicatrization was sometimes protracted for years, as happened in the following instance:—

A soldier, aged 20, was wounded at the battle of Chancellorsville, May 3, 1863, by the explosion of a shell. The integuments over the gluteal and lumbar regions were

¹ Medical and Surgical History, etc., Second Surgical Volume, p. 429.

torn off, and, on the right side, a large portion of the gluteal muscles was also removed. This huge wound is well illustrated by the accompanying wood-cut (Fig. 855). The shock appears to have been considerable. On May 8, reaction having taken place, the patient was sent to Armory Square Hospital, at Washington. He suffered but little

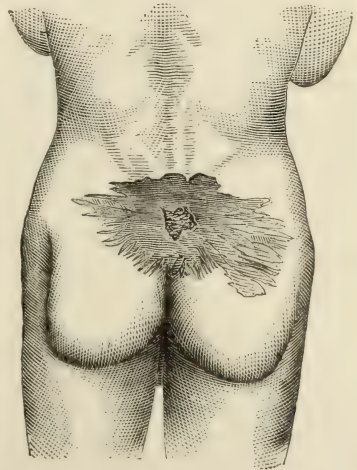
Fig. 855.



Showing an immense shell-wound of the lumbar and gluteal regions; tetanus; recovery.

pain, and had a good appetite. He was ordered the best of diet, with porter; lint wet with a disinfectant lotion to the wound; and an anodyne internally at night. The patient did well until the forenoon of the 15th, when he complained of inability to separate his jaws, and of stiffness in the muscles of the neck. The trismus was attended next day by opisthotonos and other tetanic symptoms, caused perhaps by spinal meningitis. Large doses of morphia were administered at short intervals, and with a good effect. On the 22d, a large dejection from the bowels occurred. From this date the patient steadily improved. On July 10, he was furloughed. On November 24, he returned to the hospital. On December 5, an examination showed that the wound had cicatrized, excepting a patch having the size of the palm of a hand, and that this portion was kindly granulating. The right buttock was wasted and flattened. His gait was feeble and uncertain. His general health appeared to be good. On December 15, he was discharged from the service and pensioned. A drawing in colors of the huge wound in this case, as well as of that in the preceding case, was made by Hospital Steward Stauch soon after the reception of the injury. Both drawings are preserved in the Army Medical Museum. An excellent chromo-lithograph, made from the drawing in the last case, is presented in the second volume of the Surgical History of the War. The accompanying wood-cut (Fig. 855) is a copy (reduced) of the chromo-lithograph. On November 30, 1870, the pension-examiner reported as follows in the case: "A shell-wound over sacrum of large extent; is not so well as formerly; the sore now shows no disposition to heal, and, in all probability, will remain an open ulcer. His weight is 130 pounds; the pulse 70; the respiration normal; disability total." In 1871, the late Dr. Otis, the much-esteemed editor of the Medical and Surgical History of the War, addressed a note of inquiry to this soldier, regarding

Fig. 856.



Showing the appearance of the cicatrix nine years after the wound represented in Fig. 855 was inflicted. In the centre of the cicatrix an indolent ulcer of irregular shape remains.

the condition of his wound. His attorney courteously responded to this letter, and transmitted a photograph and diagram of the cicatrix, which then bounded a raw surface of irregular shape, three inches wide by two inches in height. The photograph is reproduced in the accompanying wood-cut (Fig. 856). For a long time the granulations on this raw surface had been indolent, and the cicatrization had made no progress; there were no sinuses nor fistulous tracks to indicate the existence of diseased bone, or of any other internal cause of irritation. The invalid's general health was satisfactory. Dr. Otis advised that M. Reverdin's plan of skin-grafting, on which Messrs. Bryant and Pollock had latterly reported so favorably, should be resorted to; but, at the time of writing, he had not been informed whether this advice had been followed.¹

G. Fischer² cites the case of a French soldier, who, while kneeling, was struck by a rolling cannon ball, which carried away a portion of the buttocks having the size of a dinner-plate. In another instance, a piece as large as a man's hand was torn off. In both cases luxuriant granulations arose, and complete recoveries were expected.

Concerning the *treatment* of this class of injuries, not much remains to be said. The chief risks pertaining to them arise from a liability to the occurrence of tetanus, of spinal meningitis, of septicæmia, of pyæmia, or of exhaustion from profuseness and protractedness of the suppuration. The plans of treatment should, therefore, be framed with a view to avoid the occurrence of these complications as far as possible. To this end, the dressings applied to the wounds should always be antiseptic in their nature, a nourishing diet, with tonics and stimulants, should generally be allowed, and constitutional irritation, as well as pain, should be promptly allayed by a judicious administration of opium or morphia. The action of opiates in these cases, to allay nervous irritation, may sometimes be advantageously supplemented by exhibiting the bromides or chloral hydrate. The cicatrization of the wounds, especially when the sores are large, and have become chronic, should be aided by introducing skin-grafts, as recommended for this class of injuries by Dr. Otis.

In civil life, immense lacerated wounds of the back are sometimes inflicted with the implements of labor, accidentally or designedly. For example:—

“Dominick Jeffri, an Italian laborer, was struck in the back with a pickaxe in the hands of John Cannon, a fellow workman, and fatally injured yesterday. The men, who were recently arrived emigrants, were employed in making an excavation for gas pipes on Atlantic Street, Brooklyn, when Jeffri stepped backward in a stooping position just as Cannon's pick was descending. The full force of the blow drove the sharp-pointed, heavy pick through the back, near the spine, for the depth of five or six inches, causing the blood to flow from a terribly lacerated wound.”³

The treatment of this form of injury should be conducted on the principles which have already been laid down.

GUNSHOT (SMALL-ARM) FLESH-WOUNDS OF THE BACK.

In the Second Surgical Volume of the Medical and Surgical History of the late Civil War, at page 428, there is presented a tabular statement embracing 12,681 cases of gunshot flesh-wound of the back. The number of deaths was exactly 800, which gives a ratio of mortality of a trifle over 6 per cent. The proximate causes of death are specified in 380 of these cases. Eighty-three of them were complicated by other wounds. Of the remaining 297

¹ Ibid., p. 430.

² Deutsche Zeitschrift für Chir., 1872, Bd. I. S. 198. (Otis.)

³ N. Y. Herald, June 8, 1882.

patients, 27 are reported as having succumbed to *tetanus*,¹ 33 to *secondary hemorrhage*, and 28 to *gangrene*. The fatal termination was ascribed to *surgical or traumatic fever* in 17 cases, to *pyæmia* or *septicæmia* in 67 cases, to *pneumonia* or *hepatitis* (probably instances of embolism) in 17 cases, to *erysipelas* in 8 cases, to *typhoid fever* in 31 cases, to *diarrhœa* and *dysentery* in 39 cases, and to *peritonitis* in 7 cases. In one instance the administration of *chloroform*, it was thought, caused the fatal result. Two patients died from *diphtheria*, two from *smallpox*, and 18 from various intercurrent disorders due to "*hospitalism*," and not directly connected with the traumatic lesions. Dr. Otis makes the following observations, which may be of special interest to statisticians: "Analysis of this large series of gunshot flesh-wounds indicates that the mortality of these non-penetrating wounds has been over-estimated by some European writers of acknowledged authority in matters pertaining to surgical statistics. Making every allowance for errors, and admitting that the aggregate may have been swelled by the admission to hospital of trivial cases of wounds of the integuments, the percentage of mortality remains much lower for this group of injuries than has been heretofore represented."²

The foregoing exhibit of the causes of death which were noted in 12,681 cases of shot flesh-wounds of the back, shows that these lesions were but seldom mortal, unless *septicæmia*, *pyæmia*, *gangrene*, or *tetanus* (that is, *traumatic spinal meningitis*) supervened, or arterial hemorrhages occurred, which, doubtless, were not infrequently maltreated, and so proved fatal, as I have shown, on a previous page, was the case in numerous instances of incised and punctured wounds of the posterior cervical region. Nevertheless, *septicæmia*, *pyæmia*, *gangrene*, *tetanus*, and maltreated arterial bleedings, were encountered with such frequency in this class of injuries as to make the employment of special precautions against their occurrence a necessary feature in every plan of treatment. The destructive effects of "*hospitalism*," and of exposure to infectious disorders, such as *typhoid fever*, *smallpox*, and *diphtheria*, were likewise observed with such frequency as to require the adoption of preventive measures.

But flesh-wounds of the back, inflicted by small-arm missiles, usually—that is, in a large majority of instances—gave no particular trouble, and soon terminated in recovery. The following example will serve to illustrate this point:—

Private John Cosgrove, Company F, Eighth U. S. Infantry, aged 23, was wounded March 17, 1869, by a conoidal ball, which entered the right side of his back near the fifth lumbar vertebra, passed forward and outward, and emerged immediately over the anterior superior spinous process of the ilium. He was admitted to the post hospital at Columbia, S. C., on the 18th. Simple dressings were applied, and in April he was returned to duty.³

However, the observations collected by surgeons in several different wars have shown that there are certain forms belonging to this group of injuries, which are particularly liable to prove troublesome in respect to management, and to be followed by imperfect recovery or physical disability. For instance, Hennen found that "extensive injuries, or the permanent lodgment of balls, gave rise to either death or incurable paralysis."⁴ Stromeyer observed that, while shot flesh-wounds of the back did not in general exhibit

¹ I have no doubt that most of these 27 fatal cases of so-called *tetanus* were, in reality, examples of *traumatic spinal meningitis*, in which inflammatory irritation of the motor filaments produced tetanic spasms in the corresponding peripheral muscles.

² Op. cit., p. 432.

³ Circular No. 3, War Department, S. G. O., August 17, 1871.

⁴ Op. cit., p. 350.

a special tendency to suppuration, it frequently occurred in long transverse seton-wounds of this region that, their orifices having promptly healed and remained closed, their tracks, months afterward, filled up internally with purulent matter so as to form fluctuating tumors, which had to be lanced, inasmuch as the thick skin of the back was but slowly pierced by ulceration. He likewise remarked: "Many surgeons err in trying to relieve such ailments by several small incisions, or even punctures, parallel to the spine; these afford no relief, and it is absolutely necessary, in such cases, to make incisions several inches in length, at right angles to the spine."¹ It should also be stated, that, if the surgeon does not lay open the track of the ball, in such cases, dame Nature herself will not unfrequently do it by ulceration or sloughing. During the late civil war, I saw several examples of long, seton-like, transverse flesh-wounds of the back, in which the bridge of injured muscle and integument had been completely carried away by ulceration and sloughing, and the seton-like wound itself had been converted into an immense open sore whose long diameter extended transversely, that is, was perpendicular to the vertebral column. The cicatrices resulting from such wounds, as a rule, seriously impaired the functions of the injured muscles. Again, I also saw during the late civil war, several instances of long seton-like flesh-wounds of the dorsal region, which extended between the scapulæ in a longitudinal direction, that is, were parallel to the vertebral column. These wounds had been received by men deployed as skirmishers, while advancing by crawling on their bellies over the ground. In some of them, the missile, having passed through the trapezius, tore for itself a way across the fibres of the rhomboid muscles, dividing them to great extent from above downward, and escaped from the integuments over the latissimus dorsi. In such cases, a considerable degree of disability always remained, owing to the contraction and agglutination of the injured muscles which ensued. Furthermore, Dr. Otis remarks concerning this group of injuries: "There were some curious instances of long, circuitous, ball-tracks; and, among the fatal cases were noted several in which the projectiles had lodged under the scapula."² During the late civil war, I several times had occasion to observe that the results were exceedingly unsatisfactory, in all cases of shot flesh-wound of the back, where the missiles lodged beneath the scapula. These patients often complained of having great pain in the injured region, and begged to have the missiles extracted by operations to which they were always ready to submit; the fistulous tracks made by the missiles remained open, discharging purulent matter, while the injured muscles became matted together in consequence of the inflammation and suppuration, and the movements of the injured shoulder always remained much restricted. In one of these cases, after the lapse of many months, the missile which had penetrated above the superior angle of the scapula, and lodged beneath that bone on the inner side of the serratus magnus anticus, sank downward by the force of gravity until it rested on the costal origin of the latissimus dorsi from the last three ribs. It was extracted by making an incision through the integuments and the latissimus dorsi. Thereupon, the patient's sufferings, which had been very great, immediately ceased, and a fistulous channel, which had remained open and discharging, soon became permanently closed; but I do not think that the man ever regained very good use of the injured shoulder.

Dr. B. Beck³ remarks, in substance, that when the fleshy covering of the back is injured, much depends on the depth to which the laceration of the muscles extends, the length of the shot channel, the amount of concussion (as

¹ Quoted by Otis, op. cit., p. 429.

² Op. cit., p. 430.

³ *Chirurgie der Schussverletzungen*, 1872, S. 448. (Quoted by Otis, op. cit., p. 430.)

from large shot or shell fragments), and the degree of implication of the ribs or spine. Shot wounds limited to the areolar tissue and muscles mainly, are of no special interest, unless attended by exceedingly large loss of substance, or by a very long, seton-like ball-track. Cases in which bloodvessels of the larger order, and the main branches of nerves, are contused or lacerated, are more serious. The functions of the dorsal muscles are, in some cases, much impaired by shot lacerations. Many invalids of this class are unable to move freely, and complain of difficulty in breathing, stooping, turning the head, etc.; complications due, unquestionably, to cicatrices resulting from lacerated shot wounds that have either been attended by sloughing, or have required incisions to relieve deep suppuration. These observations of Dr. B. Beck confirm those of other surgeons, which have been presented above.

Flesh wounds of the back from small-arm missiles, especially when much inflamed, may be attended by paraplegia, as happened in the following case, which Staff-surgeon T. P. Matthew declares "may be accepted as typical of many wounds of this region:—"

"Maurice Garvey, aged 19, was wounded, on 8th June, by what he supposed to be a spent ball, which struck him on his back about opposite the seventh dorsal vertebra. On admission to his regimental hospital, there was immense swelling of the back, and complete loss of motion of both lower extremities, but not of sensation. The swelling in great measure subsided in a few days, under the use of fomentations, when two wounds were discovered, giving the idea of entrance and exit of a ball, but no injury of the bones of the spinal column could be detected. The wound healed under simple dressings, but the paralysis continued, and he was transferred to the Castle Hospital, on 24th October. Here, under the impression that the persistent paralysis might be due to chronic inflammation of the theca vertebralis, he was twice put under the influence of calomel, with diuretics, and upon each occasion with, it was thought, marked benefit. Subsequently strychnine was given, in sufficient quantity to produce convulsive spasms of the affected limbs. This did not seem productive of any good, and, after persistence in its use for three weeks, it was omitted. He very slowly improved, however, and on 26th January, was invalided to England, having got comparatively fat, and able to stand upon the affected limbs, and even walk a few paces with the help of crutches."¹

Was the motor paralysis, which presented itself in this case, due to extension of the inflammatory process which arose in the injured tissues of the back, and caused immense swelling inwardly until it reached the theca vertebralis, etc., or was it due to concussion of the spinal cord? This question no one can authoritatively decide, although the fact that mercurials and diuretics proved markedly beneficial on two occasions, decidedly favors the idea that there was a secondary spinal meningitis.

Treatment.—Flesh-wounds of the back made by small-arm missiles should be carefully explored at the outset, and all foreign bodies, including spent balls, fragments of clothing and of equipments, and all coagula, should be promptly extracted. If there be arterial hemorrhage—whether primary, intermediary, or secondary—it must be suppressed by exposing to view the wounded vessel at the place of injury, and ligaturing it on each side of the aperture in its walls. The occurrence of septicaemia, pyæmia, and gangrene, must be obviated as far as possible by applying antiseptic lotions, such as a ten-per-cent. solution of alcohol in water, to which two per cent. of carbolic acid has been added, with a view to increase its efficacy. Drainage tubes should be inserted in all wounds where the purulent matter exhibits a tendency to stagnate, or does not readily flow away. Pain and constitutional irritation should be subdued by administering opiates and sedatives. A nourishing

¹ Med. and Surg. History of the British Army in the Crimea, vol. ii. p. 337.

diet should generally be allowed; and, not unfrequently, wine, bitter ale, porter, or alcoholic liquors should also be prescribed. But the most important of all the points concerned in treating this group of injuries, consist in promptly removing all foreign bodies, in dressing the wounds antiseptically, and in draining them thoroughly by passing appropriate velvet-eyed India-rubber tubes of suitable size into them deeply, or completely through them, which is still better. When arterial bleeding occurs in this group of injuries, to such an extent as to constitute surgical hemorrhage, the wounds should not be stuffed with plugs soaked in ferric persulphate or perchloride solutions, neither should these liquids be injected into them, for both proceedings are worse than useless in such cases; on the contrary, the bleeding vessel should be promptly exposed to view at the place of injury, by enlarging the wound itself or by direct incisions, and then it should be tied with two ligatures, one of them being applied on each side of the aperture in its tunics; and, finally, it should be completely divided midway between the ligatures, so that both ends may retract, and thus considerably lessen the liability to return of the hemorrhage. Instructions on this point of treatment are by no means idle or unnecessary, for during the late civil war (as has already been stated) no less than thirty-three fatal cases of secondary hemorrhage from flesh-wounds of the back, inflicted by small-arm missiles, were reported by our military surgeons.¹

It is advisable, however, to add that *parenchymatous hemorrhages* from flesh-wounds of the back, when due to occlusion by coagulated blood (thrombosis) of the veins proceeding from the injured part, or to any other cause, must sometimes be treated by covering the raw or granulating surface from which the blood is exuding, with compresses of lint thoroughly wetted with a solution of persulphate or perchloride of iron; but arterial hemorrhages must not be treated in this manner.

SPRAINS, TWISTS, AND WRENCHES OF THE BACK.

The several bones which compose the vertebral column, that is, the true vertebræ themselves, together with the sacrum and coccyx, are united to each other, and to the bones that lie in contact with them, by ninety-nine joints or articulations. All of these joints are more or less susceptible of motion. In some of them, however, the degree of mobility is but slight, as for instance, in the sacro-coccygeal articulation; in others, it is very considerable, as for example in the occipito-atloid and atlo-axoid articulations. The several bones which constitute the vertebral column are likewise strongly bound together by ligaments, a considerable proportion of which are elastic. A brief enumeration of these ligaments may aid us materially to comprehend the effects of sprains, wrenches, and jars of the vertebral column: (1) The lenticular disks of *intervertebral substance*, interposed between the bodies of all the vertebræ from the axis to the sacrum, perform not only the office of ligaments, but they also have elastic properties, which enable them to act in a manner not very unlike that of India-rubber buffers, when placed between the cars of a railway train, in obviating the injurious effects of jars and shocks upon the vertebral column itself, and upon the organs contained in the spinal canal. (2) The *anterior* and *posterior common ligaments* likewise bind together the bodies of the vertebræ. (3) The *ligamenta subflava* gird together the arches of each pair of vertebræ, from the axis to the sacrum. These ligaments are also elastic; and by means of their elasticity, they counteract the

¹ Med. and Surg. History, etc., Second Surgical Vol., p. 432.

efforts of the flexor muscles of the trunk, so that in maintaining an upright position of the vertebral column, they lessen considerably the expenditure of muscular force by their automatic work. (4) The *capsular ligaments* and *synovial membranes* hold together the articular processes of the vertebræ. (5) The *inter-spinous* and *supra-spinous ligaments* fasten together the spinous processes in the dorsal and lumbar regions. (6) The *inter-transverse ligaments* connect the transverse processes of the lower vertebræ with each other.

Furthermore, the *ligamenta subflava* are in direct relation, by both surfaces, with the *meningo-rachidian veins*; and, internally, they are separated from the dura mater of the spinal cord by these veins and some loose connective and adipose tissue. A laceration of these ligaments would probably be attended by a rupture of these veins. Again, the *posterior common ligament* is in relation by its anterior surface, not only with the intervertebral substances and the bodies of the vertebræ, but also with the *venæ basum vertebrarum*. It is in relation by its posterior surface with the *dura mater of the spinal cord*, some loose connective tissue and *numerous small veins* alone being interposed. A laceration of the posterior common ligament would probably be attended by a rupture of these veins, with a rupture of the *venæ basum vertebrarum*, and a considerable injury of the spinal dura mater. Indeed, the anatomical relations of the *ligamenta subflava* and the posterior common ligament are such that traumatic spinal meningitis, as well as hemorrhage from the contiguous veins, might readily result from a traumatic lesion involving either of them.

Violent strains and forcible flexures, and strong twists or wrenches of the back, produce injuries of the joints and ligaments of the vertebral column, and of the adjacent parts, both soft and hard, which are strictly analogous to the lesions that result from the same kinds of hurt when they affect the joints of the extremities. The lesions which are met with in the back, in consequence of these forms of injury, vary from a slight laceration of some fibres of the vertebral ligaments, and of the contiguous connective tissue, and lesser bloodvessels, on the one hand, all the way up to a very extensive tearing through or detachment of the vertebral ligaments, with a correspondingly extensive rupturing of the contiguous muscles, tendons, connective tissue, and bloodvessels, on the other. Indeed, the lesions which result from severe sprains and twists, or wrenches of the vertebral column, differ only in degree from those which attend dislocations of the vertebræ. But, according to the observations of Mr. Hilton, "the most frequent lesion in injury to the spine is a partial severance of the vertebra from the intervertebral substance."¹ This view receives support from the fact that the junction of a more to a less elastic body is the weakest spot, and, therefore, receives the full effect of a strain.²

The *symptoms* or phenomena which attend these accidents are pain in the injured parts, and inability to move them, with tumefaction and tenderness under pressure in the same region; and, not unfrequently, subcutaneous ecchymosis appears in the swelling. These symptoms, however, all vary in degree and extent, according to the amount of the injury that has been sustained. The swelling may or may not be attended by ecchymosis; and sometimes the latter does not make its appearance for several days. The tenderness under pressure is usually not restricted to the spinous processes of one or two of the vertebræ (which circumstance, if it were present, would excite a suspicion that vertebral fracture existed), but is equally noticeable over several contiguous spinous processes. At the same time, on tracing the tips of these spinous processes, they are found to be in a normally straight line, and on a

¹ On Rest and Pain, Am. ed., pp. 47, 48.

² Ibid., p. 48, foot-note.

proper level. So much at present concerning the immediate effects of these accidents.

Among the remote effects of the lesions of the back, especially when they have been neglected or improperly treated, are permanent lameness of the back from chronic inflammation of the injured joints, and curvature of the spinal column from vertebral caries. Mr. Hilton thinks that severances of the vertebræ from the intervertebral substances, when inadequately treated, are particularly liable to give rise to vertebral caries.¹

Among the possible consequences of sprains or wrenches of the vertebral column, spinal meningitis must likewise be mentioned. The following statement concerning a case, in which a wrench of the back was received while on board of a street railway car, has recently been printed, on apparently good authority, in a prominent morning paper in New York:—

“As one turns into Sixteenth Street off Union Square, on the west side, one notices the tan-bark laid thickly in front of a handsome house in the middle of the block. Here lies G. G., the popular soubrette of the *Théâtre Comique*. She stopped a car a few weeks ago, and the conductor started it before she had fairly got on, giving her such a wrench and start that she felt at the time a severe pain in her back. From that day to this she has been unable to move, lying dangerously ill with spinal meningitis.”²

SPRAINS, TWISTS, AND WRENCHES IN THE CERVICAL REGION.—No other cases of spinal injury or disease are so immediately dangerous to life as those in which the upper part of the cervical region is the seat of injury, but especially the first and second cervical vertebræ, or the space between them; for, when spinal paralysis results from injury or disease of this part of the cervical region, the nerves which cause the respiratory muscles to act are likewise paralyzed, and then complete stoppage of the respiratory movements, or death, instantly ensues. Mr. Hilton has reported a number of cases which give so much information of very great value to both surgeons and patients concerning this group of injuries, especially about their symptoms, consequences, and treatment, that my work were but illy done should I omit to mention them. Concerning a case where death from pressure upon the spinal marrow was impending, which ultimately ended in recovery, he says:—

“In 1850, I was requested by Dr. Addison to see, with him, a young woman, suffering from injury in the upper part of the spine, the result of an accident. I found her almost pulseless, with great distress in breathing, loss of voice, inability to swallow, and nearly complete paralysis of the arms and legs. She had had, from the early part of her illness, severe pains spread over the back of her head and neck, increased on pressing the head downward upon the spine. Her symptoms had gradually arrived at this stage of danger, without benefit of medical treatment. I might here say, that the difficulty of breathing and deglutition had so greatly increased of late, that it was thought necessary, or to her advantage, to lift her up more and more in the bed; but the change of posture seemed only to add to her distress in breathing and swallowing. These were the difficulties for which my assistance was requested. She was then propped up in bed by pillows at her back, with her head inclined somewhat forward, or dropping upon the chest. As the impediment to swallowing was almost an insurmountable difficulty, I was desired to examine the throat, but I could not discover anything wrong in it. It was our opinion that her life was in imminent, or perhaps, instant danger. She was paralyzed, and could not swallow; her voice was excessively feeble, and her pulse not very perceptible; she scarcely breathed at all, and was not quite conscious. It was evident that something must be done without delay. Believing that her symptoms resulted from the odontoid process of the second vertebra pressing upon the spinal marrow, close to the *medulla oblongata*, I advised that she should be made to lie down immediately. On saying to her, ‘You must lie down in bed,’ she

¹ *Ibid.*, p. 48.

² *N. Y. Sun*, June 4, 1882.

replied, in the smallest possible voice, 'Then I shall certainly be killed; I can't get my breath.' Seeing there was no time for contention, I told her our opinion was, that, if not placed longitudinally in bed, she would in all probability die in a very few minutes. Being paralyzed, or nearly so, she could offer no resistance to my purpose; and I shall never forget the weight of the responsibility, when I took hold of her, desired the pillows to be removed from her back, and, supporting her head and shoulders in my arms, slowly placed her upon her back, nearly flat upon the bed, with her head upon a thin pillow, some additional support to the hollow of her neck, and two sand-bags, one on each side of her head, to prevent any lateral or rolling motion. Here was a patient in the greatest possible danger, and I do not hesitate to express the opinion, that, if the head had fallen forward, say half an inch, she would have died in an instant. Her sense of suffocation was soon relieved by the horizontal position, and she remained lying down during six months uninterruptedly, at the end of which time all the serious symptoms had disappeared. She was then allowed to move about the ward, with caution; and, a few months afterward, left the hospital, well, with the exception of a stiff neck, most probably depending on ankylosis, or bony union, between the atlas and the axis. In this case, nothing but complete rest was employed as a remedy; rest was the only element of success in the treatment, and I think it is a very striking example of its power to prolong life, by enabling Nature to repair her injuries undisturbed."¹

In this case, the sprain or wrench of the joints between the atlas and the axis was followed by chronic inflammation of these joints, of a destructive character, which, happily, terminated in a cure by ankylosis, under the benign influence of prolonged rest. The severe pain over the back of the head and neck, which helped to mask the vertebral lesion, for some time, was due to irritation of the occipitalis major and minor nerves, and, perhaps, of other branches of the anterior and posterior cervical plexuses of nerves, also.

Mr. Hilton continues in a most instructive vein:—

"I will now direct your attention to another case of diseased cervical vertebræ (also caused by a hurt), which terminated in sudden death. It is that of a little child, five years and five months old, seen by me in 1841. She was a small, delicate, unhealthy girl. She had been accustomed to ride a good deal in the country, with her mother, in an open carriage, and was thought, in that way, to have caught a cold in the back of the neck, which became gradually stiff and swollen, accompanied by pains in the head and neck. These pains were believed to be rheumatic, and the treatment employed had reference only to that impression, which was supposed to be supported by some pain experienced in the limbs, with cramps and stiffness in walking. She frequently suffered from fever and loss of appetite, and had been under medical treatment during many weeks, the symptoms slowly increasing in severity. The mother told me afterward that she had thought her an obstinate child, and that she sometimes threatened to punish or to shake her well because she would not take her food. I have no doubt, if she had done so, she would have killed the child. Upon careful examination, I thought I made out the case to be one of disease between the first and second cervical vertebræ, or thereabouts. I say thereabouts, because the parts were too much swollen, and too painful, to admit of a more accurate local investigation. There was pain at the back part of the head, in the course of the great occipital nerve; pain behind the ear, in the course of the great auricular, and of the small occipital; pain in the higher part of the neck, on rotation of the vertebræ upon each other; and pain in the same vertebræ, probably the first, second, and third, by pressing the bones upon each other. She had some difficulty in deglutition, and the voice had lately changed its character, and become more feeble, indicating that the pneumogastric nerves, and possibly the spinal accessory, were involved in the mischief. Thus, having, in common with the surgeon in attendance, recognized the real nature of the case, directions were given that the child should be placed upon her back, with her head resting upon a thin pillow, and some additional

¹ Op. cit., pp. 60, 61

support to the nape of the neck, each side of the head to be supported by sand-bags, so as to prevent any lateral or rotary movement in the neck. It was plain that, if the life of the child was to be prolonged or saved, it could only be accomplished by a long-continued rest to the spine; and, for the purpose of securing easy rest to the little patient, a water-bed was sent from London, and the child was safely placed upon it, with the sand-bags extending from the shoulders to beyond the head. In about a fortnight the nurse specially appointed to attend the child, finding that her rest at night was now so calm and quiet, that she was so free from pain and fever, that her appetite and power of swallowing were so much improved, as well as her temper, and thinking she was altogether so much better, and willing, no doubt, to mark her own penetration, as well as to please the mother by telling her in the morning what had been done by her little charge—this meddlesome and officious woman, instead of giving the child her breakfast, as usual, without disturbing her head or neck in the least degree, desired the child to sit up to breakfast. The child did so; the head fell forward, and she was dead. The *post-mortem examination* proved that disease existed in the articulations between the first and second cervical vertebræ, that the bones were loose, and that, when the head with the atlas fell forward, pressure had been made upon the spinal marrow, close to and below the medulla oblongata, at the point of decussation, so that the child was killed almost instantly, as in pithing animals. This was a case in which both the surgeon and nature were completely thwarted. The local disease was considered at the time to be dependent upon a constitutional or a scrofulous cause; but I have since understood that it was the result of a blow given to the little girl by her brother, who struck her with something he had picked up in the room. It was not constitutional; there was no visceral disease of any kind.”¹

In this case, then, there was a destructive inflammation of the joints between the atlas and the axis, arising from a blow upon, or a wrench of, these joints, and the real character of the lesion was, for a long time, overlooked; but, in all probability, it would have been cured, as the preceding case was cured, by proper and long-continued rest, had nature and the surgeon not been thwarted by the misadventure. Moreover, the morbid condition of the atlo-axoid articulations, which was revealed by the autopsy, in this case, sheds a flood of light upon the pathogenesis of the preceding case, and frees it from all obscurity or doubt. Thus, the history of this case is the complement of that of the preceding case, and fully elucidates it.

Mr. Hilton also relates the case of a lady, aged about 30, who had a disease of the spine affecting the occipitalis major and minor nerves, the third cervical nerves, and the nerves forming the left axillary plexus, that was caused by a blow on the left side of the head with a bolster, or cushion, which forcibly displaced it laterally, and thus strained or wrenched the joints of the first, second, and third cervical vertebræ. She fell upon the carpet, and was unconscious for some little time. She had, as reported to herself, a sort of struggling fit. On recovery, she was put to bed; and, in a day or two, nothing remained of the accident, excepting some tenderness in the upper part of the neck; but, soon afterward, the symptoms about to be described came on. When Mr. Hilton first saw her, some nine or ten months after the injury, “she had pains on the left side, at the back of the head, and at the posterior part of the external ear; pain over the clavicle and shoulder (all on the left side); pain, with loss of power, in the left arm; pain deep in the neck, on pressing the head directly downward upon the spine, and on rotating the head; some fullness and tenderness on pressure about the first, second, and third cervical vertebræ, especially on the left side. She could not take walking exercise in consequence of the increasing severity of all the symptoms. She had almost sleepless nights, and her appetite was very poor. It was obvious that there existed some disease or injury of the spine affecting the occipital nerves, the third cervical nerves, and the nerves forming the left axillary plexus. As far as I [Mr. Hilton] could interpret the case, rest appeared to be the proper remedy. The patient maintained, almost uninterruptedly, the recumbent position, during nearly three months, two sand-

¹ Ibid., pp. 61, 62.

bags being placed one on each side of the head. The only medicine employed was one-sixteenth of a grain of bichloride mercury twice a day, during about two months. At the expiration of three months the patient had lost all pain and tenderness, and had regained the use of the arm, neither did pressure nor rotation of the head induce pain. The fullness in the neck had also disappeared."¹ To conclude the case, this lady left town, and, afterward, reported herself quite well, being perfectly cured.

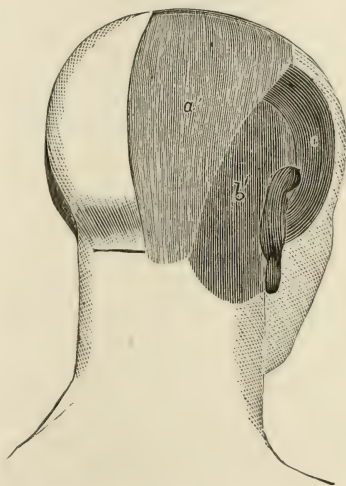
The wrench of the vertebral column, in this example, appears to have been attended with cerebral concussion, caused by the same blow on the head which produced the sprain of the neck, and there was loss of consciousness for some little time. She was placed in bed, but she was not kept there long enough for the injured joints connecting the first, second, and third cervical vertebræ together to become sound again. The consequence was, that, as soon as she got up and began to go around, the inflammation in the sprained joints increased, the contiguous sensory nerves became irritated thereby, and pains appeared in the parts to which they were distributed, that were mistakenly considered to be rheumatic pains; and so the poor lady went on for nine months, constantly under treatment for rheumatism and hysteria, but getting worse the whole time. Rest, that is, enforced quietude of the injured articulations, was the sole means of importance, which finally secured her recovery; and the same means, had it been applied to her case at the outset, for only a few weeks, would have saved her from a year of intense suffering.

"The next case is that of a surgeon," writes Mr. Hilton, "who was in the yacht of another gentleman. Running along from one part of the ship to another, he struck his head against the top of a door, and was thrown backward with great force. Very shortly afterward he had pain in the distribution of the occipital nerves at the back part of the head and the back of the neck. [See Fig. 857, *a*, *b*.] Six weeks from that time (he still continued in the yacht), having experienced some increase of pain, and heard and felt a grating sensation in his neck, he was somewhat alarmed, and came to me, suffering from pains indicating disease of the second or third cervical vertebra. He was ultimately cured by lying down—that is, by rest. On the 8th of February last he came to me perfectly well, and says he was quite cured by *rest*. Time will not permit me to dwell on the details of this surgeon's case."²

In order to illustrate the varieties in strains of the neck, together with the symptoms and treatment of recent cases, the following examples must be briefly presented:—

A young carpenter, while stepping backward, tripped on a heap of planks, and fell upon his back. His shoulders were received on the planks; but, his head and neck projecting beyond them, the neck was abruptly bent backward with much force. Swelling at the back of the neck, from occiput to scapulæ, so great as to be visible at a distance, appeared soon after the accident. He was unable to keep his head erect; and before attempting to do so, placed a hand on each side to steady it. He was placed in bed. At the end of a month, having been provided with an artificial support, he was made an out patient.³

Fig. 857.



Showing, *a*, the portion of the scalp supplied by the occipitalis major nerve; *b*, the portion supplied by the occipitalis minor nerve; *c*, the portion supplied by the auriculo-temporal nerve. (Hilton.)

¹ Ibid., pp. 54, 55.

² Ibid., pp. 55, 56.

³ Holmes's System of Surgery, 2d ed., vol. ii. p. 359.

Again, a shoemaker, aged 32, while stooping, tripped and rolled over, with his head under him. His neck received thereby a twist that caused much pain. He lay motionless, flat on his back, for ten minutes, being without the power to move both arms and legs, and having a sense of numbness and of pricking throughout the body. In trying to stand, his legs gave way under him, as if he were intoxicated. Sensation, also, was impaired but not lost. Within twelve hours, however, both motor power and sensation were restored; and the paralysis did not return. He complained of acute pain in the neck, which was aggravated by the slightest movement of the head; and he, therefore, kept the head perfectly still. He lay in bed, on his back, with his neck sunk on to a low soft pillow, and propped up by sand-bags. On examination, the chief tenderness was found at the fourth cervical vertebra; and there a deeply seated swelling was perceived. For treatment, absolute rest of the neck was enforced, and tincture of iodine applied. In a month he was allowed to leave his bed, with his head supported by a plastic shield extending from the shoulders to the occiput. He could then perform the nodding, but not the rotatory, movements of the neck. In nine weeks, all the cervical movements seemed quite restored; but, for precaution's sake, he was kept in hospital three weeks longer. He returned to his trade, and called several times afterward to show that he was well.¹

Finally, a little, rickety girl, of 3 years, having a large head, was admitted to hospital, late one evening, with paralysis of the upper and lower extremities. She had fallen out of bed, that morning, head-foremost, and was insensible for a few minutes. During the day, it was remarked that she did not get upon her feet, nor move her legs; and that she did not use her hands. When examined, motor power was found to be lost in both upper and lower extremities. She showed no signs of pain when the skin was pricked anywhere below the upper part of the chest. Reflex movements were excited in the lower extremities when the skin of the abdomen, and it alone, was pricked; and then the child gave a slight cry of pain; respiration natural; bladder and rectum not affected. She uttered cries whenever the neck was moved, or the back of it was pressed on by the fingers; and, after it, seemed pleased to keep the head at perfect rest on a pillow. For three days no change in the symptoms was observed; on the fourth day there were visible signs of improvement; on the fifth, it was discovered that she could freely move both upper and lower extremities, and that motion of the head had ceased to give pain. There was no further trouble, and she remained quite well.²

The main point in the treatment of recent, as well as in that of old cases, in which the articulations of the cervical vertebræ have been sprained or wrenched, is to maintain them in a state of complete immobility and relaxation until the cure is complete. To this end, the patient must be made to lie continuously in bed, on the back, with only a thin pillow under the head, and barely enough support under the nape of neck to keep it from sinking. Besides, to keep the head straight, and to prevent its rolling from side to side, sand-bags, that are sufficiently long and heavy to fulfil the indications, must be so placed upon the patient's pillow, one on either side of the neck and head, as to give both of the parts a complete lateral support. Indeed, I do not know of any other mechanical expedient, of a simple nature, which answers this purpose as well as sand-bags, made of bed-ticking, of a length sufficient to extend beyond the head, and about three-fourths filled with dry sand. One of them is to be placed with care on each side, close to the neck and head, and is to be accurately moulded thereto, so as to keep the head entirely straight, and to render all lateral or rotatory movements of the parts impossible.

SPRAINS, TWISTS, AND WRENCHES IN THE DORSAL REGION.—The dorsal portion of the vertebral column, when compared with the cervical and lumbar portions, is characterized by a relatively much greater rigidity and want of

¹ Ibid., p. 359.

² Ibid., pp. 359, 360.

flexibility or capacity for movement upon each other of the several bones that compose it, at the articulations by which they are linked together. The injuries caused by sprains and twists, or wrenches, in this region are, therefore, somewhat analogous to those produced by enormously powerful blows, and their deleterious effects are apt to be restricted to the articulations which connect two contiguous vertebræ, instead of being dispersed or diffused so as to affect the articulations of many adjoining bones, as is usually the case with similar injuries in the more flexible parts of the vertebral column, the cervical and lumbar regions.

There is a traumatic, as well as a rheumatic, "crick" in the back, which is not unfrequently caused by lifting, or attempting to lift, a heavy weight while in a stooping position, and is located in the dorsal region. The victim, while exerting his strength to the uttermost in this position, suddenly feels "something give way" in his back, and is soon seized by cramping pains in the affected part, which are aggravated by all attempts to produce motion therein; so that he carefully abstains from making such attempts himself, and is only too glad if the injured part be allowed, by the exigencies of life, to remain in a state of absolute quietude. In such cases, the muscular fibres belonging to the strained part are sometimes lacerated to a considerable extent, and the effusions of blood and of inflammatory products into the injured muscular and connective tissue may cause tumefactions, possibly with subcutaneous ecchymoses also, which can readily be felt and seen externally. For such cases, the best plan of treatment consists in the enforcement of absolute quietude as long as the soreness continues, with the external use of a mildly stimulating liniment, and the internal administration of opiates, whenever necessary to allay the pains.

Sprains and wrenches of the dorsal part of the vertebral column are sometimes caused by alighting on the dorsal region in falls, or when thrown from the saddle while on horseback. They are also produced, occasionally, in military life, by the trampling of horses upon the backs of men who have suddenly been dismounted, or have been thrown down to earth by other means, in battles or in sham-fights.

The vertebral ligaments and joints may likewise be sprained or wrenched by the impact of powerful blows on the dorsal region, no matter what the instrument may be that inflicts them. In respect to treatment, no additional directions are required.

The natural curvature of the dorsal part of the vertebral column, the convexity of which looks backward, undoubtedly exerts considerable influence in the way of lessening the injurious effects upon the vertebral ligaments and articulations, of violent blows on the dorsal region. This circumstance probably explains why it is that heavy blows on this part of the back are so seldom attended with strains or wrenches of the vertebral column, that prove troublesome to manage, or even require a surgeon's care. The principal effect of strong blows, etc., when received on the convexity of the vertebral arch in the dorsal region, is to compress the intervertebral substances, and the articulations in general, which enter into the formation of the arch; and, therefore, they usually do comparatively little harm to the spine. But a much more powerful blow—one, for instance, that falls but little short of dislocating or fracturing a dorsal vertebra, and so comes very near to breaking down the dorsal arch—may readily detach the corresponding intervertebral substance, to greater or less extent, from the bone, and thus cause an inflammation which may prove destructive to the injured bone and cartilage, especially if the lesion chance to pass unrecognized, or happen to be inadequately treated. It is not improbable that caries of the dorsal vertebræ sometimes begins in this way.

The mechanical effects of falls, however, are widely different from those of blows on the dorsal portion of the vertebral column, especially when the victim's back happens to alight upon some solid body of comparatively small dimensions, whose upper surface is considerably raised above the surrounding ground—for instance the stump of a tree, or a block of wood, etc.; for, in such a case, when the further descent of the back is stopped by striking against the solid body, the downward movements of the head, neck, and upper extremities on the one hand, and those of the abdomen, pelvis, and lower extremities on the other, are not arrested at the same instant of time as that of the dorsal region; and, therefore, the weight and impetus of these parts simultaneously press downward, with great energy, upon both the upper and lower ends of the arch formed by the dorsal vertebræ, and on the concave side thereof, in such a manner that the intervertebral substances and bodies of the dorsal vertebræ are in the line of extension, and the spinous processes of these vertebræ in that of compression. It is obvious that a comparatively slight fall upon the dorsal region, occurring in this way, may badly stretch or strain the anterior and posterior common ligaments of the spine, and may also separate to a considerable extent the intervertebral substances from the bones. It is highly probable that caries of the dorsal vertebræ, in consequence of falls upon the back, not unfrequently originates in this manner; and that comparatively trifling accidents of this sort may, under favoring circumstances, suffice to produce this result.

SPRAINS, TWISTS, AND WRENCHES IN THE LUMBAR REGION.—The vertebral column is sprained and twisted, or wrenched, in the lumbar region, more frequently than in any other part thereof. Such lesions of the lumbo-vertebral articulations are sometimes produced in attempting to lift great weights while in a stooping position; and by the impact of blows and falls upon the lumbar region itself, quite analogous to those in the dorsal region which have just been discussed. More often, however, they are caused by accidents in which the vulnerating force is indirectly applied to the lumbar region; for instance, by alighting on the buttocks in falling from a height, or by the falling of a heavy weight upon the head or upper part of the body, while it is in an erect posture, the lower extremities being firmly planted on the ground. Many years ago, a good example of the first-mentioned kind of accident came under my observation:—

A young farmer, aged about 20, accidentally slid down from a steep hay-mow, and then falling about fourteen feet, struck the ground upon his buttocks. He received thereby a violent jar in the lumbo-sacral region. His head and shoulders sank backward to the earth, where he lay for some time, unable to arise, barely able to move his legs a little (they also felt benumbed), and suffering terribly from pains in both lumbar regions. At first, he thought his “back was broke.” However, after he had lain wet with cold sweat for some little time, he began to feel less faint, or a little stronger, and found himself able to move his lower extremities rather better. The pains, too, gradually abated, and then turning himself partly over, he tried to make his way to the house by crawling on his belly; but these efforts increased the lumbar pains so much that he was compelled to desist. After lying quite still, a little longer, he found that the paralysis of his lower extremities was considerably lessened, and that possibly he might arise. After many efforts he succeeded in doing so, his legs, meanwhile, having given way under him several times like those of a drunken man. He walked with the feeble and uncertain steps of an intoxicated person, from the weakness of his lower limbs; but after much effort, he succeeded in getting to the house, a distance of about two hundred yards, without any assistance. He was immediately placed in bed. There was considerable swelling across the loins, and much tenderness was discovered by pressing upon the lumbar spinous processes. Tenderness was also discovered in and around the bodies of the last three lumbar vertebræ, on pressing upon them through the front wall

of the abdomen. There was no displacement of the bodies or spinous processes of the vertebræ. For several days, the loins were fomented with a strong decoction of chamomile flowers and wormwood. His favorite posture in bed was that of lying upon the side (it did not seem to matter which side), with his body semi-flexed, and knees drawn up. For many days he was reluctant to make any change whatever in his posture, because of the excruciating pains in the lumbar region, which every little twist or flexure of the injured articulations of the spine, and every contraction of the lumbar muscles, gave rise to. As continuous confinement to bed was enforced, the first important evidence that he was recovering was noted when he began to move himself about in bed, of his own accord. On discontinuing the fomentations, a large belladonna plaster was applied to the loins. He was confined to bed just four weeks, and the complete rest of the injured parts, thus secured, was the chief means relied upon to promote his recovery. He wore belladonna plasters, and complained of feeling lame and weak in the lumbar region for a long time afterward; but, in the end, he perfectly recovered.

In this case, the articulations of the lumbar vertebræ were wrenched in a peculiar manner. The young man's buttocks, in falling from a height of fully fourteen feet, struck the ground with great force. At that instant, the lower part of the spinal column was suddenly compelled to support the weight and impetus, or momentum, of all parts of the body situated above the loins, the first effect of which was to compress the intervertebral substances, to be followed, however, in an instant afterward, by a violent bending of the spinal column backward, at the peculiar curvature formed by the lumbar vertebræ on top of the sacral curvature. The greatest part of the strain, therefore, fell upon the articulations of the last three lumbar vertebræ; and, at the same time, the intervertebral substance and the bodies of these vertebræ were in the line of extension. In this way, the anterior and posterior common ligaments of the spine, and the intervertebral substances, in the lumbar region, together with the psoas muscles, were all severely stretched; and this circumstance accounts for the fact that much tenderness under pressure was discerned on examining the lumbar vertebræ through the front wall of the abdomen. The nature of the lesion also explains why it was that the attempt to crawl on the belly caused so much increase of the pains in the injured part; for, on elevating the shoulders in order to execute the movements which constitute crawling, the injured vertebral ligaments and muscles were again put on the stretch.

A good illustration of the last-mentioned kind of accident, in which the vulnerating force is indirectly applied to the lumbar region, was lately under my care:—

E. B. C., aged about 60, while walking in the second-story hall of an old house, January 21, 1882, entirely oblivious of danger, was suddenly struck on top of the head by a mass of plastering, estimated to weigh over two hundred pounds, that, having become loosened, had fallen down from the ceiling, which itself was rather lofty, being about sixteen feet high. The blow on the head, of course, was exceedingly violent; it gave him a scalp-wound two and one-half inches long over the right parietal bone, with severe concussion and contusion of the brain. His body was also bent forward, and doubled up, by the force of the blow on the head and the weight or momentum of the falling mass of plastering, so that he was instantly crushed down to the floor, where he lay stunned for some little time. The forcible bending forward and doubling up of his body took place at the loins; and thus the lumbar muscles and the articulations of the first, second, and third lumbar vertebræ were badly strained. Obviously, the structures of the fore-part of his spinal column suffered powerful compression at the place of forcible flexure, while those at the back-part thereof were subjected to violent elongation and overstretching. The cerebral lesion masked to a great extent the subjective symptoms of the lumbar lesions, for a considerable time; but, objectively, there soon arose a swelling across the injured loins which attained the thickness of a man's hand, was very tender under pressure, and lasted a long time. The quietude and other remedial mea-

tures that the cerebral contusion demanded, were sufficient to relieve the lumbar lesions also, so that no special medication was ordered for the lumbar region until April 12, when a large belladonna plaster was prescribed, giving much relief. His recovery, however, was not complete (as to the loins) until the 1st of June.

Usually, considerable swelling across the loins soon follows such injuries of the lumbar region as have just been described. Subcutaneous ecchymosis may or may not attend the tumefaction. Sometimes the ecchymosis does not appear until several days after the accident. On tracing the spinous processes with the fingers, their positions are found to be the same as in the normal state. On examining the bodies of the lumbar vertebræ through the anterior wall of the abdomen, no displacement is detected. Tenderness under pressure, in such cases, is usually observed over a considerable space. Oftentimes the patient, with evident difficulty, and much exhibition of pain and weakness in the loins, will endeavor to place his vertebral column in an erect position; if his efforts be successful, and no deformity be presented, it may confidently be assumed that there is no fracture. The posture which patients having lumbar sprains generally assume in bed, is, as described above, that of lying on one side, with the trunk semi-flexed, and the knees drawn up; and, for many days, they are usually reluctant to make any change of position, from dread of the pains and spasms in the injured muscles, which all attempts at movement are liable to excite. When such patients begin to move themselves about in bed, of their own accord, they furnish the best possible evidence of progress toward recovery.

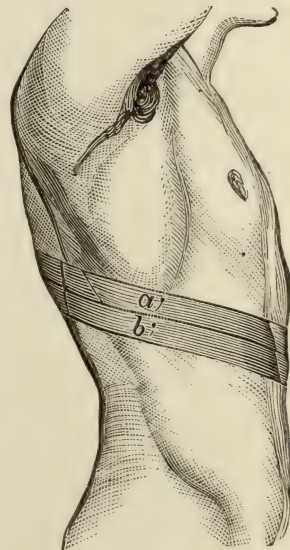
The *treatment*, as shown above, does not differ essentially from that of sprained joints in general. The most important point is to enforce absolute quietude of the injured parts for a sufficient length of time. Commonly, it requires from four to six weeks' confinement to bed for recovery to take place. If the bowels be at all confined, a mercurial purge may be administered with advantage. If there be febrile movement of a sthenic character, saline drinks may be given with benefit, and the diet should be low while it continues. Should the lumbar pains or the muscular spasms prove troublesome, they may be quieted by exhibiting opium in the form of Dover's powder. The diet must be nourishing in asthenic cases, and in all others likewise after the acute stage has been passed. Fomentations with decoction of poppies, applied to the injured loins, also appear to do good. But those which consist of a strong decoction of chamomile and wormwood (mentioned above), are perhaps still better. At a later period, camphorated oil, or camphorated soap-liniment, should be used instead of fomentations. The patient, when about to leave his bed, should be furnished with a riding-belt stiffened with additional whalebone. (Shaw.) At the same time, a large belladonna plaster can generally be applied with benefit.

INFLAMMATION OF THE VERTEBRAL ARTICULATIONS ARISING FROM SPRAINS, TWISTS, OR WRENCHES.—From such injuries, an inflammation of the over-stretched or lacerated ligaments, tendons, muscles, and connective tissue, more or less severe according to the nature of the case, soon ensues. This appearance of inflammatory reaction in the damaged tissues is a necessary consequence of the original lesions. Its occurrence should, therefore, be anticipated, and its treatment should likewise be provided for by the surgeon from the very outset of the case. Moreover, this traumatic inflammation may, in general, be completely controlled by patiently applying the principles and methods of treatment just enunciated. But when the presence of traumatic inflammation in the vertebral joints happens, from any cause, to be unrecognized, or, if recognized, to be made light of, and when, therefore,

the disorder receives no treatment whatever, or at best is very inadequately treated, then the inflammatory process is quite liable to become chronic and suppurative in character, and, in the end, to destroy the vertebral articulations involved, just in the same way as the joints of the extremities are destroyed by disease under similar circumstances. It is this chronic or consecutive disorder of the vertebral articulations, that not unfrequently results from sprains and twists, or wrenches, of the vertebral column, which we have now to consider. It is, perhaps, more often met with in cases where the symptoms of injury originally are not severe, than in cases where they are strongly marked; for, in the latter instance, the severity of the symptoms themselves will be apt to secure that thoroughness and sufficiently long continuance of treatment which is indispensable for recovery. However this may be, it nevertheless is certain that this disorder not unfrequently appears in cases where the symptoms of vertebral injury have been originally by no means severe; and sometimes, too, in cases where the symptoms of vertebral injury have been comparatively slight at the outset, so that the disastrous consequences have unexpectedly ensued. When the articulations of the spine that have been damaged by sprains, etc., are occupied by chronic inflammation, they are liable to exhibit at first gradually increasing tumefaction and induration; then indolent suppuration, like that which takes place in other joints that are similarly affected, and, finally, ulceration of the cartilages and caries of the vertebræ.

Among the earliest symptoms in these cases, not unfrequently, are pains, located not in the spine itself, but in the parts supplied by the terminal branches of the sensory nerves which issue from the vertebral column at the seat of the lesion, and give rise to the pains, because their filaments are irritated by the inflammatory process going on in the intervertebral foramina through which they pass. Several examples have already been presented where disease of this sort, situated between the first and second cervical vertebræ, was attended by pains located on the back part of the head, behind the ears, etc., because the occipitalis major and minor nerves with the auricularis magnus were irritated in this manner within the spinal column (see Fig. 857). In such cases, the pains due to the spinal disease are apt to be mistaken for rheumatic pains, and to be maltreated accordingly. In like manner, pains at the pit of the stomach may be caused by diseases of the dorsal vertebræ, which irritate the sixth and seventh dorsal nerves (see Fig. 858). Mr. Hilton presents two examples which well illustrate this point. Both patients, however, made good recoveries, by adopting rest as the chief remedial agent, and without applying anything to the dorsal region.¹ Mr. Hilton also points out that these pains are almost always symmetrical, that is, alike on both sides of the median plane, when they arise from disorders in the lower cervical, dorsal, or lumbar vertebræ, whilst they often are uni-

Fig. 858.



Side view of the chest and abdomen, showing the course of the sixth and seventh dorsal nerves. (Hilton.)

¹ Op. cit., pp. 48-50.

lateral, or one-sided, when caused by disorders between the occiput and the atlas, or between the atlas and the axis. The most probable explanation of this peculiarity is, that a spinal disorder occurring between the occiput and the atlas, or between the atlas and the axis, may be confined to only one of the joints between these bones, whilst a disorder of the lower cervical, dorsal, or lumbar vertebræ, generally involves the bodies of the vertebræ or the intervertebral substances, entirely or completely.¹ I have, however, lately seen a case wherein pains of this sort, that were caused by chronic inflammation following a wrench of the lumbar vertebræ, appeared on one side only.

The following case, which is related by Mr. Hilton, illustrates the symptoms of this lesion, when it involves the eighth and ninth dorsal vertebræ, in a most useful manner:—

It is that of a moderately robust little girl, aged $4\frac{1}{2}$ years, who, while enjoying good health, fell down out of bed upon her back, a distance of about two feet. But nothing appears to have been thought of it at the time, though she at once began to lose flesh, and her face become anxious. About three months afterwards, she began to complain of symmetrical pains in her belly, was easily fatigued also, and stooped a little in walking. Her fall upon the back having been forgotten, she was treated for the abdominal affection by several surgeons, but rapidly grew worse instead of better. She became much reduced in flesh and strength, and unable to walk about, from spasmodic pinching pain in the abdomen, which “doubled her up.” In a short time, however, having been kept quiet in bed, she recovered her flesh and strength, so as to be enabled to walk about a little without pain. But, quickly, all the untoward symptoms again supervened; the abdomen became large and tumid, the bowels irregular, with pain in the belly, as if a cord were drawn tightly around the abdomen and tied. Another surgeon was now consulted, who declared the mesenteric glands affected. The urine was phosphatic and ammoniacal. She was allowed to go about as usual. In a short time the alteration and unsteadiness of gait became more marked, and, the other symptoms continuing, she was taken to London for advice. Disease of the eighth and ninth dorsal vertebræ was detected, with slight projection backward, or angular curvature. Her fall upon the back had recently been remembered. Uninterrupted rest in the recumbent posture was ordered, with no medicine, and the child completely recovered in four or five months.²

It is apparent that in this case the real cause was, for a long time, entirely overlooked; that the abdominal symptoms were treated as depending on some error in the abdominal viscera, when they wholly depended on the spine; and that the spinal condition itself was meanwhile altogether ignored. Nevertheless, almost all the symptoms which attend chronic inflammations of the vertebral joints, in consequence of neglected sprains and wrenches, were present in this case. For example, there were pains in the belly, which were due to irritation of the sensory filaments of the ninth pair of dorsal nerves. There were also cramps or muscular spasms in the belly, which were caused by irritation of the motor filaments of the same pair of nerves, during their passage through the intervertebral foramina. Besides, there was paraplegia (incomplete), which probably resulted from compression of the spinal cord. The urine, too, became phosphatic and ammoniacal, and the bowels tympanitic, in consequence of accompanying myelitis. Moreover, the appearance of angular curvature of the spine, at the seat of injury, served to show exactly what joint was sprained, and the nature of the disorder which invaded the bodies of the contiguous vertebræ in consequence of the articular lesions. By adding to this account of the symptoms, a statement that tenderness under pressure and some swelling of the soft parts were found over the eighth and ninth dorsal vertebræ, which without doubt was

¹ *Ibid.*, pp. 51, 52.

² *Ibid.*, pp. 52, 53.

the case, a complete picture of the symptoms pertaining to the disorder in question is presented. So much, then, for the symptoms which are liable to result from traumatic spinal arthritis, when it becomes chronic and advances unchecked for some considerable time; or until caries of the bodies of the contiguous vertebræ ensues.

Caries of the vertebræ, however, will not be specially discussed in this article, as it will be fully dealt with elsewhere. Inflammation of the vertebral joints is here considered only in so far as it is a consequence of sprains and twists or wrenches of these joints, and in so far as it becomes necessary for surgeons to thoroughly understand the symptoms, final results, and treatment of these hurts, in order to recognize their importance, and take care of them in such a manner as to save patients from the great evils which, when neglected, they are liable to cause. To this end I have presented the foregoing examples and observations that illustrate these forms of injury, and the principles which should guide their treatment. It is necessary, still, to point out briefly some direful consequences of these lesions which have not yet been mentioned, and which are as follows: (1) The consecutive inflammation may extend to and destroy the spinal nerves that are contiguous to the injured articulations, and thus cause permanent paralysis of the parts which they supply. (2) The consecutive inflammation may spread from the joints of the spine to the theca vertebralis, and thus induce spinal meningitis. What then is chiefly to be apprehended is, that the product of this meningeal inflammation, on being effused into the spinal arachnoid cavity, may compress the spinal cord so as to arrest its functions, and thereby cause paraplegia, or even death. (3) The consecutive inflammation may spread still further toward the centre, and attack the spinal cord itself, thereby causing spinal myelitis, and, in this manner, paralysis with a fatal result. Happily, however, there is not the same risk that an inflammation which involves the bones of the vertebral column will spread inward, and successively attack the spinal meninges and the spinal cord, as there is, in cases where the cranial bones are inflamed, that the inflammatory process will spread inward and successively attack the cerebral meninges and the cerebral substance; for, in the head, the dura mater, being firmly adherent to the cranium, performs the office of an internal periosteum, whilst, in the spine, not only does each vertebra possess a distinct periosteum, but the theca vertebralis, or spinal dura mater, is also comparatively free, being attached by a very loose connective tissue only to the walls of the spinal canal. Whilst the cranium, the cerebral meninges, and the brain itself, are formed in close connection with each other, the vertebral column, the spinal meninges, and spinal cord are formed in loose array; and, therefore, an inflammation cannot extend itself from one structure to another, through contiguity, in the latter organs, with anything like the same facility that it can in the former.

After long and wide experience, Mr. Hilton concludes: "I have generally found that almost all these diseases of the spine are the result of slight accidents overlooked."¹ It has been shown in the preceding pages, that slight falls upon the back, especially on the dorsal region thereof, and where the intervertebral substances and bodies of the vertebræ are situated in the line of extension, and the laminae, spinous processes, etc., in that of compression, may be attended by detachment (more or less extensive) of the intervertebral substances from the vertebral bodies, and that these lesions, if overlooked or maltreated, can lead to all the evil results that have been mentioned above. The importance of continuous rest in bed, as a remedial measure, in such cases, cannot be over-estimated, and must not be forgotten.

¹ Ibid., p. 52.

HÆMATURIA FROM CONTUSIONS AND SPRAINS OF THE BACK.—Traumatic lesions of the kidneys, with bloody urine, occur so frequently in cases where severe contusions and strains, or wrenches, are sustained in the lumbar regions, that a pretty full account of them is necessary in this place.

The source of the hemorrhage, in these cases, it is seldom difficult to determine; for, when blood is found intermingled with the urine, after such injuries of the loins, it may generally be inferred with safety that one (at least) of the kidneys is also injured. When, however, slender, cylindrical, pale pieces of fibrin, or dark-colored coagula having a similar shape, are seen in the urine, the surgeon may be sure that the blood has come from the kidney, for these clots have been moulded in the ureter and then have been washed down therefrom by the urine. Moreover, when blood is passed intimately blended with the urine, but without coagula, in cases of lumbar injury, it has likewise, in all probability, a renal origin.

It will be remembered that the kidneys are two dense and rather brittle glands which lie close to the sides of the spinal column from the first to the third lumbar vertebræ inclusive, and outside of the peritoneum; that they are surrounded, and held in place with considerable firmness, by connective tissue containing much fat; that the right kidney lies rather lower than the left; and that each of them projects downward below the last rib, and, behind, is covered by the quadratus lumborum muscle. Hence, all violent flexures of the upper lumbo-vertebral articulations from sprains or wrenches are liable to be attended by corresponding bends and breaks of the kidneys; hence, also, the impact of powerful blows on the lumbar muscles may readily be transmitted through these muscles to the kidneys themselves, with enough force to contuse or even tear those organs. Finally, the renal lesion in these cases, whether consisting merely of contusion, or of slight rupture, or of extensive laceration of the renal substance, is usually attended by hæmaturia.

But, when the kidneys contain calculi, and when they are congested, as, for example, in the first stage of Bright's disease, or when their texture has become weakened, as, for instance, in chronic parenchymatous nephritis, comparatively slight injuries of the lumbar region may be attended by hæmaturia.

The clinical features or characteristics of the above-mentioned forms of renal injury can best be presented by the narration of some examples. In military life, the blow on the lumbar region which causes the mischief, may result from the explosion of a shell, as happened in the following instances, two in number, which were reported during the late civil war:—

J. H. P., Co. K, 142d Pennsylvania Vols., aged 20, was struck on the left lumbar region, July 2, 1863, at Gettysburg, by a large fragment of shell, which caused a grave contusion with ecchymosis, but without abrasion of the skin. There was shock, and much pain and tenderness at the injured part, and the urine was scanty and bloody. The pain extended along the course of the ureter, and there was retraction of the testicle with smarting at the orifice of the urethra. There was much difficulty in micturition, and occasionally tubular clots of blood were passed, after which the urine flowed in a stream, with great relief. The patient was also suffering from diarrhœa. He was treated with hot fomentations applied to the injured part, and with chalk mixture and spirit of nitric ether, until the 11th, when he had rallied sufficiently to be transferred to the Satterlee Hospital, at Philadelphia. There he was treated with infusion of buchu, together with counter-irritation applied to the loins; and, as soon as the irritability of his bowels permitted, he was placed on nourishing diet, with ferruginous medicines, and bitter tonics. The hæmaturia disappeared after the third week from the reception of the injury. The patient gradually convalesced, and, on December 31, 1863, was transferred to the Invalid Corps.¹

¹ Med. and Surg. History of the War of the Rebellion, Second Surgical Vol., pp. 20, 21.

This example affords a good clinical illustration of the traumatic lesion of the kidneys, by which powerful blows on, or violent contusions of, the lumbar regions, are not unfrequently accompanied. The renal symptoms were very clear. They were shock, pain in the bruised and torn kidney, which extended downward along the course of the corresponding ureter, with retraction of the testicle on the same side, and smarting at the urethral orifice. The urine was bloody, and, at times, contained also coagula which had been moulded in the ureter. At such times the act of urination was very difficult, and the difficulty lasted until the coagula had passed through the urethral canal. Their voidance was always followed by copious urination, and by a sense of great relief. The hæmaturia continued for three weeks, but the patient gradually recovered.

From the nature of the vulnerating force, from the presence of shock, from the intensity and persistency of pain in the injured kidney and its excretory duct, etc., from the long continuance of hæmaturia, and from the severity of the renal symptoms in general, it is but just to infer that the renal lesion in this case was extensive, and probably consisted of laceration as well as contusion of the renal parenchyma. Notwithstanding, the patient slowly regained his health. This point is of much practical importance; for, aside from other considerations, the happy result helps to show that rupture of the kidney is an accident from which recovery is more common than it is from a similar lesion of any other important viscus.

The next case belongs to the same category as the last:—

Lieutenant H. T. Burrows, Co. C, 7th Maryland Vols., was struck May 5, 1864, by a fragment of shell, on the left lumbar region. He was treated during one week at the second division hospital of the Fifth Corps, in the field. Severe pain and difficult micturition, with hæmaturia, led to the belief that laceration of the left kidney had resulted. On the 12th, this officer was sent to Washington, and there was treated in quarters. He recovered; and, on June 8, he was placed on court-martial duty.¹

Besides the examples just related, there were also observed, during the late civil war, “a number of cases of recovery in which there was reason to suspect the existence of laceration of the kidney, or, at least, of severe contusion of its substance. Unfortunately, they are not reported with fulness or precision of detail.”² Taking these cases, however, for what they are worth, they will serve to increase considerably the aggregate of instances in which traumatic lesions of the kidneys, attended with hæmaturia, and caused by lumbar contusions, have eventuated in cure; and, for this reason, I have thought it worth while to mention them.

Mr. Shaw refers to the case of a woman who had been bruised in the loins, from the falling in of the roof of her dwelling; and who, it was claimed, had sustained a renal lesion thereby.³ Albuminuria also was present.

When great strains or wrenches of the vertebral articulations in the lumbar region are caused by alighting upon the feet in falling, the kidney may be extensively ruptured at the same time, as happened in the following instance reported by Dr. Anders:—

A well-built lad, aged 15, fell from the second floor of a house to the ground, without becoming insensible. He said that he struck the ground first with his feet, and then with his right hip. No external mark of injury, excepting a slight purplish spot over the right trochanter. No fracture of any kind, and no symptom of concussion of the brain or spinal cord. He could not walk very well, but was able to move his

¹ *Ibid.*, p. 21.

² *Ibid.*, p. 20.

³ Holmes's *System of Surgery*, 2d edition, vol. ii. p. 363, foot-note

extremities freely when lying in bed. Pulse 60, and small; sensibility not decreased. He freely passed bloody urine. He complained of severe pain in the abdomen, especially in the left renal region, but nothing abnormal could be detected by inspection or palpation. The microscope showed the urine to contain a large number of red blood-corpuscles. Well-marked symptoms of internal hemorrhage appeared and increased; and, at 11 A. M. next day, he died in consequence of inward bleeding. During the night the urine was very little bloody. In the morning it was quite clear. *Autopsy.*—A dark-blue tumor of the size of a child's head, extending from the iliac fossa to above the tenth rib, and covering the three superior lumbar vertebræ, was found in the abdominal cavity. It consisted of coagulated blood, wherein the left kidney, which had been torn into two distinct halves, was found imbedded. The rupture was transverse, extending from the anterior superior part of the organ to the posterior inferior, through the capsule and the parenchyma. The pieces of the kidney were about two inches distant from each other, and entirely separated from their adhesions. The left ureter was torn across, and was attached, to the length of two inches, to the lower fragment; the corresponding renal vein and artery were in the same condition. The right kidney was perfectly sound. The peritoneum was not ruptured. No fluid was contained in the abdominal cavity, and no blood in the bladder.¹

In this case, the left kidney, together with the accompanying ureter, renal vein, and renal artery were torn completely across, while all the other organs were unaffected; and the force which caused this immense laceration had been indirectly applied.

The *rationale* of the hæmaturia was probably as follows: The blood being still liquid, for some hours after the accident, flowed down through the severed ureter into the bladder, and this sanguinolent flow continued until the ureter itself became plugged by the formation of coagulum. Then the urine which was secreted by the right kidney remained clear, that is, unstained with blood, and in that condition was discharged in the morning before the patient died.

But, the lacerations of the kidneys which result from falling upon the feet, buttocks, or back, etc., are, for the most part, also attended with lacerations of other important viscera, as was observed in the following instance recorded by Professor Fayrer:—

The patient, a Hindoo, aged 25, fell from a tamarind tree, and fractured both arms. He was brought to the hospital, and appropriately treated; but the wounds did not do well, and he died in consequence of tetanus, sixteen days after the event. There was no indication of internal mischief beyond a complaint of pain in the epigastrium on the day after the accident, when uniformly bloody urine, without any clots, was passed. Next day, the urine was also bloody, but there was nothing more till death. *Autopsy.*—At the upper end of the left kidney was a rupture running into the hilus, where the areolar tissue was infiltrated with blood. A great part of this kidney was softened. There was some coagulated blood over the kidney and left side of the pelvis, but no peritonitis. Two ounces of blood clots lay in the great omentum. The spleen had two ruptures in its posterior edge, the upper one being very deep. The liver had a superficial rent on the posterior margin of its right lobe, and two others on the under surface. The liver was also studded with light-gray pyæmic patches, which Professor Fayrer attributed to emboli from the ruptured spleen. The heart and great vessels were found to contain coagula.²

In the example just presented, hæmaturia appeared on the second day, and constituted a prominent symptom. It was also the form of hæmaturia that characterizes renal injury, when no coagula are voided in the urine. It lasted, however, only two days, although it was caused by a rupture at the upper

¹ Med. News and Abstract, January, 1880, pp. 41, 42; also Brit. Med. Journal, Oct. 18, 1879.

² Med. Times and Gazette, May 18, 1867; also, New Sydenham Society's Biennial Retrospect, 1867-8, p. 187.

end of the left kidney, which extended into the hilus. The patient died sixteen days after the injury, of tetanus; and, at the autopsy, a great part of the torn kidney was found to be softened.

Sometimes, the liquid voided by urination, in these cases of renal injury, consists of almost pure blood, as was specially noted in the following instance:—

Private Henry Greene, Co. H, 9th Cavalry, entered hospital at 6 P. M., December 15, 1870, at Fort Quitman, Texas, having been run over by a wagon at 8 A. M., while on his way to Fort Quitman from Eagle Springs. It was thought that both wheels of one side had passed over his right hip and thorax. The patient was suffering, when admitted, from shock and extreme depression. His extremities were cold, and he was almost pulseless at the wrist. But he was perfectly conscious; the beating of his heart was feeble but regular, and 104 per minute; respiration 44. Death from shock and internal hemorrhage ensued at 7.30 A. M. of the following day, "the patient having passed, through the night, a quantity of nearly pure blood from the bladder." *Autopsy*, ten hours after death.—"A large effusion of blood into the abdominal cavity was found, and a longitudinal rupture of the right kidney, throughout nearly its entire extent. The bladder was normal and empty." The liver also was ruptured through almost the whole of its antero-posterior diameter, following the junction of the right with the left and quadrate lobes, to within an inch of its anterior margin. The sternum was fractured at the junction of its upper and middle third. The eighth rib (right), too, was fractured two inches in front of its angle.¹

Dr. Roddick reported the following case in which pure blood was passed, and exhibited the specimen. A healthy woman, aged 60, had fallen down a long flight of stairs, and was picked up insensible. There was no wound, but on recovering consciousness she complained of great pain in the right loin; vomiting began, and, in spite of all treatment, continued to the end. The bowels became tympanitic and refused to act. Pure blood was passed from the bladder during the first twenty-four hours; subsequently, the urine was mixed with blood, and on the fourth day it was nearly clear. Rupture of the kidney was diagnosed, and ileus was suspected on account of the obstruction of the bowels and their great distension, though no tumor could be felt. Rectal injections were employed without any benefit. At the autopsy a large clot of blood was found surrounding the right kidney, which presented a laceration on the border, extending into the pelvis of the organ. The kidneys were firm and slightly granular. The bowels were distended but not obstructed; it was thought that perhaps the large blood clot might have pressed upon the ascending colon and produced the obstruction.²

Prognosis.—Hæmaturia from contusions and sprains, or wrenches, of the lumbar region is, in most instances, not a very dangerous symptom; for usually it disappears in the course of a few days, without leaving any trace of organic disease of the renal tissue behind. Concerning hæmaturia from this cause, Le Gros Clark says that among the many cases he has witnessed, he has never had reason to suspect that nephritis or organic disease followed in any.³ On the same point Mr. Shaw remarks: "When such an important gland as the kidney has been crushed and broken, to such an extent that hemorrhage goes on from a rent in it for several days, it might be thought probable that the damage would be followed by ulterior bad results, especially that inflammation—nephritis—would ensue. But extensive observation negatives this view; general experience shows that when patients recover from the immediate effects of hæmaturia brought on by sprain of the spine, they are not more prone than others to renal complaints."⁴ In regard to hæmaturia from sprain of the back, Mr. Bryant observes: "It is not generally a very serious

¹ Circular No. 3, S. G. O., August 15, 1871.

² Medical News, November, 18, 1882.

³ British Medical Journal, October 3, 1868.

⁴ Loc. cit., pp. 362, 363.

symptom, unless the kidney is ruptured; as a rule, it disappears gradually, and no evidence remains that organic renal disease is ever the consequence.¹

Concerning the *symptoms* and *prognosis* when *rupture of the kidney* is present, Mr. Bryant also says: "When not very severe, and uncomplicated with other injuries, such cases usually do well. It [that is, rupture of the kidney] is generally known by an attack of hæmaturia and local pain following a blow on the lumbar region. The hæmaturia may be but slight and passing, or not show itself until the second day. It may cease also after the lapse of two or three days, when it is probable that only a contusion of the kidney has taken place; for, in more severe injuries, the bleeding may last fifteen days or even more. At times clots will be passed, assuming the shape of the ureter, and I have before me the notes of some half dozen cases in which these symptoms were present, and from which recovery took place. These clots, however, at times give rise to retention of urine by blocking up the urethra. Retraction of the testicle is an occasional symptom, and so is pain in the course of the ureter."² This paragraph sums up so clearly and so tersely the symptoms, etc., of rupture of the kidney from contusions and strains, or wrenches, of the lumbar region, as they severally presented themselves in the examples related above, that I have quoted it in full.

It should, however, be noted that in one of these examples (it was recorded by Professor Fayrer), although the hæmaturia did not appear until the second day, and lasted only two days, the autopsy revealed a rupture at the upper end of the left kidney which extended into the hilus, instead of a renal contusion; but it is probable that such a limitation of the hæmaturia is rather exceptional than otherwise, in cases where the rupture is so extensive.

In the last two of the illustrative cases presented above, the urinary discharge was observed to consist of pure or nearly pure blood. Nevertheless, the loss of blood from hæmaturia, when caused by contusions and sprains of the back, is rarely so great as, *per se*, to endanger life. Mr. Shaw, however, relates one case where there was good reason for alarm:—

The patient was a young man. Although the sprain was not very severe, the renal hemorrhage was uninterrupted, and unusually profuse, during the first four days; it nearly ceased for two days; then it returned, and continued for two days, with its former profusion; it now ceased for one day; it appeared, however, on the next day, the tenth, in great quantity; but then it ceased permanently. The patient, meanwhile, had become blanched and excessively weak.³

In this case, the large quantity of blood that was discharged from the urinary organs, together with the rapid appearance of the signs of acute anæmia, clearly indicated the danger. So, likewise, in all those rather infrequent cases of hæmaturia where the prognosis is not favorable, the general symptoms will sufficiently indicate the peril. The proofs of strong shock and great depression may present themselves. If the liver or spleen be also ruptured extensively, there will, too, be unmistakable signs of internal hemorrhage. Besides, the torn viscus may exhibit considerable tenderness under pressure.

Wounds of the cortical or secretory portion of the kidney are represented to be less dangerous than wounds of the tubular or excretory portion of the gland. (Agnew.) It is probable that this proposition is also applicable to the lesions of the kidney which are caused by contusions and sprains of the back.

Treatment.—Hæmaturia, when very profuse, should be combated by administering the fluid extract of ergot, in half-drachm doses, three or four times a

¹ Practice of Surgery, p. 205, Am. ed. 1879.

³ Loc. cit., p. 362.

² Ibid., p. 432.

day, together with gallic acid, in ten-grain doses, at the same intervals. In some sthenic cases, however, it may be advisable to give, instead of these remedies, the acetate of lead, in styptic doses of two grains, every hour or two, until relief is obtained. But, generally, the employment of ergot and gallic acid should be preferred.

Pain in the injured kidney and ureter, etc., is to be combated with opium or morphia; but, at the same time, these narcotics must be exhibited with caution. Rest in bed should be enjoined, together with a milk diet. When coagula form in the bladder, and cannot be spontaneously passed by the urethra, causing retention of urine, they should be broken down by injecting warm water through a large-sized catheter.

The *medico-legal* relations of hæmaturia from contusions and sprains of the back still remain to be considered. Mr. Shaw relates the case of a gentleman who claimed in a law court compensation from a railway company, for Bright's disease resulting from injuries received in a railway collision. The injuries consisted of a bruise over the right ilium and side of the loins. On the following day he observed blood mixed with his urine; and, for four days, he continued to pass blood. At this time his urine was found to contain albumen, and it continued to be albuminous from the date of the accident to that of the trial, a period of eleven months. The medical witnesses for the plaintiff held that the albuminuria, that is, the parenchymatous nephritis, had been caused by the injury of the right kidney that was inflicted in the collision. The medical witnesses for the defence (Mr. Shaw was one of them) "expressed a strong opinion that the plaintiff was suffering from the disease when he met with the accident, and that the injury could not have brought it on."¹ But, to say "that the injury could not have brought the disease on," in this case, is tantamount to asserting that a traumatic lesion of the kidney, which manifests itself by hæmaturia appearing on the day following the accident and continuing for four days, cannot give rise to a structural disease of the kidney of an inflammatory character. Such an assertion cannot reasonably be maintained; for Professor Fayrer, in the case of the Hindoo, related above, who had hæmaturia beginning on the day following the accident, and lasting only two days, and who died in consequence of tetanus sixteen days after the injury, found at the autopsy that there was a rupture of the left kidney extending into the hilus, and that a great part of this kidney was softened, that is, had become the seat of a structural disease, and had undergone a structural change, such as is not unfrequently produced by the inflammatory process; or, in other words, that the rupture of the kidney had been attended by traumatic nephritis. There is, therefore, no reason for doubting that, in at least occasional instances, the injury of the kidney which causes hæmaturia, gives rise also to Bright's disease. In the case just mentioned, the jury, notwithstanding the medical testimony adduced by the defence, "awarded heavy damages to the sufferer," and it may well be that the verdict was a righteous one.

A legitimate inference from the foregoing, which has value for medico-legal uses, is, that although some surgeons of large experience have never seen a case in which hæmaturia from contusions and sprains of the back was followed by nephritis or by organic disease of the kidney, nevertheless, such cases do sometimes occur; and that, whenever they do occur, their existence ought to be recognized. It is also pretty certain that Bright's disease does not often arise from renal traumatism; but, precisely how often, future experience alone can determine.

¹ Loc. cit., p. 363.

HEMORRHAGE INTO THE VERTEBRAL CANAL FROM SPRAINS, VIOLENT FLEXURES, AND TWISTS, OR WRENCHES, OF THE BACK.—This accident has no surgical importance, unless paraplegia more or less complete ensues. In the cases where it occurs, the chief proximate cause of disability and danger to life is the compression of the spinal cord, or of the spinal nerves before they issue from the intervertebral foramina, which the extravasated blood occasions. As in the cranium, so also in the vertebral column, the extravasated blood which compresses the nerve-tissue may be effused between the dura mater and the bone, that is, externally to the dura mater, on the one hand; or internally to that membrane, that is, between it and the nerve-structures, on the other. We are, therefore, liable to meet with both extra-dural and intra-dural hemorrhages, of a perilous character, in the vertebral canal as well as in the cranial cavity.

It has already been stated, in this article, that the ligamenta subflava are in direct relation with the *meningo-rachidian veins*, and that laceration or violent stretching of those ligaments would pretty certainly be attended by rupture of these veins; also, that the posterior common ligament is in relation, by its anterior surface, with the *venæ basæ vertebrarum*, and by its posterior surface, with the dura mater of the spinal cord, from which it is separated only by the *plexus venosi spinales interni* or longitudinal spinal sinuses, with some loose connective tissue containing fat, and that laceration of this ligament would be likely to be attended by rupture of these venous plexuses or sinuses, and, possibly, by rupture likewise of the dura mater of the spinal cord. Moreover, the laceration or violent stretching of these ligaments is liable to be attended by rupture of the arteries which, on entering the vertebral canal, come into relation with these ligaments as well as with the intervertebral disks, namely, the *rami spinales*. The arteries which may be ruptured are numerous, the veins are not provided with any valves which could prevent regurgitant hemorrhage, and the dura mater is attached but very loosely to the inner surface of the vertebral canal. Thus, it appears, that when the vertebral ligaments are much torn by sprains, violent flexures, and twists, or wrenches of the vertebral column, there are many bloodvessels from which hemorrhage may occur if these vessels also be torn open, and that ample means are afforded by looseness of the connective tissue for the extravasated blood to accumulate, in great masses, between the dura mater of the spinal cord and the bone, as well as within the hollow cylinder or sheath which is formed by the dura mater itself.

When, in such cases, the hemorrhage soon ceases, and the quantity of the extravasation is not large, it is probable that recovery will ensue; for the effused blood will be more or less completely absorbed, and thus the spinal cord will be more or less completely freed from compression. But, when the hemorrhage continues unchecked, the paraplegia arising therefrom will increase, and it will gradually spread upward until the superior extremities, too, become paralyzed; and finally, the functions of the phrenic nerves will likewise be suspended, the diaphragm will no longer contract, the respiratory movements will entirely cease, and then death will of course immediately result, as happened in the following example which occurred in the practice of Dr. John J. Crane, of New York, and in which I assisted at the autopsy:—

Mr. S., an actor, aged about 50, sustained a violent injury in the root of his neck, shoulders, and back, from being thrown thereon while wrestling, on a Sunday afternoon. Being unable to arise without assistance, he was picked up and laid upon a bench by those around. Afterward he was put into a coach; and, being held in a semi-recumbent position, he was carried to his home. Dr. Crane saw him, for the first time, about nine o'clock P. M. He was then unable to move his lower extremities, and exhibited all the symptoms of paralysis from spinal injury, so far as they were con-

cerned. His urine, however, was passed voluntarily, the bladder and abdominal muscles being unaffected. The upper extremities, also, were not paralyzed.

On the following morning (Monday) it was found that the paralysis had reached a higher point, that there was retention of urine, and that catheterization was necessary. Afterward, the paraplegia continued steadily to advance, travelling up the trunk, involving the upper extremities, involving likewise all the respiratory muscles excepting the diaphragm, and, finally, attacking the origin of the phrenic nerves, when he immediately ceased to breathe. He died on Wednesday night, somewhat more than three days after the accident. His bowels were moved only once, and then by enema, on Tuesday morning. He complained of pain only in the lower part of the neck, and exhibited signs of severe suffering whenever his head was moved. There was tenderness under pressure, and considerable swelling in the lower and back part of the cervical region. But no displacement or irregularity of the spinous processes, nor of any other parts of the vertebræ, could be detected. His mind was clear to the end.

The *autopsy* revealed a very extensive effusion of blood within the theca vertebralis, which distended that membrane and compressed the spinal cord throughout almost the whole of its extent, namely, from the cauda equina up to the superior cervical region. The spinal cord itself was not wounded. The theca vertebralis was ruptured to the extent of about one-third of its circumference, in the lower part of the cervical region. The ligaments connecting the fifth, sixth, and seventh cervical vertebræ exhibited much laceration. A fissured fracture also passed longitudinally through the fifth, sixth, and seventh cervical vertebræ. There was not much displacement of bone, certainly not enough to press on the spinal cord in any way, and not enough to be cognizable by external examination. The blood found within the theca vertebralis was, for the most part, extravasated from the vessels of the cord—that is, from the arteriæ spinales, anterior and posterior; but, no doubt, some blood from without had entered the cavity of the theca vertebralis through the ruptured aperture in that membrane. It was, however, evident that the paraplegia had slowly crept upward in this man's body, just as the effused blood accumulated in the thecal cavity, commencing in the lower end thereof; and, that death had resulted from compression of the spinal cord, arising from this cause.

In the very instructive case which has just been related, there was a longitudinal fissuring of the last three cervical vertebræ, as well as such a laceration of the ligamentous tissue and neighboring bloodvessels as is often found in cases of sprains, from contusions and violent flexures of the vertebral column. Still, the case practically belongs to the same category as sprains and wrenches of the vertebral column, because several vertebral articulations did, in fact, sustain the lesions which characterize this form of injury, and examination during life did not and could not reveal any lesion of the vertebral column, excepting the sprains of the vertebral joints. Moreover, if in this case there had been no intra-theal hemorrhage, and no compression of the spinal cord, or had the effusion of blood been moderate, and had it been followed by absorption, the patient's recovery might easily have ensued; and had his recovery so ensued, the fissures in the last three cervical vertebræ would never have been discovered, and the injury would have been considered as merely a sprain or wrench of the back. But, at all events, this example illustrates in an excellent manner the clinical history, that is, the symptoms which are likely to present themselves, in fatal cases of compression of the spinal cord from the extravasation of blood within the spinal dura mater, where life is prolonged for three or four days.

To illustrate compression of the spinal cord from hemorrhages which occur externally to the spinal dura mater, Mr. Shaw relates at much length the case of a woman, aged 60, admitted to the Middlesex Hospital under his care, in March, 1841, having been injured in the back by falling down a flight of steps shortly before:—

No irregularity in the line of the spine could be perceived; and, although she sat up for examination, there was no particular part of the back which seemed to be particularly weak. Both upper extremities and the right lower extremity were deprived of voluntary motion; but sensation was nearly perfect, for she spoke only of a little numbness in them. Reflex movements could not be excited in the paralyzed upper extremities, while they were particularly lively in the paralyzed lower extremity. The breathing was not disturbed. There was at first retention of urine; and, for a few days, incontinence; but soon afterward she regained the natural control over urination. The bowels acted regularly. During the first ten days no perceptible change took place; but in the following fortnight a slow and gradual increase of power over the paralyzed limbs was observed; after that, however, all progress seemed to cease. She was retained in the hospital for three months; but her subsequent history is not known. "That in this case," says Mr. Shaw, "the blood which escaped had been poured into the loose space intervening between the osseous walls of the canal and the theca spinalis seems most probable; and, also, that the source of the blood was the venous sinuses which line the interior of the canal in the form of plexuses." He further says: "As the paralysis was partial, three alone out of the four extremities being affected, and motor power being the only property lost, it may be inferred that, if blood extravasated external to the theca were the compressing agent, it had been collected in the canal in unequal quantities at different parts. Such an hypothesis would explain how one of the lower extremities escaped being deprived of its motor power."¹

But, inasmuch as there was no autopsy in this case, the conclusion that intra-vertebral hemorrhage had occurred externally to the theca vertebralis must be held to be unproved, and as at least to that extent uncertain.

Dr. Deville, in 1843, in examining the body of a man who had died in consequence of falling from a great height on to the pavement, found, on laying upon the spinal canal, a most extensive extravasation of blood, completely filling up this canal in its whole length, and extending upward, even beyond the point where the spinal cord had been cut across, when the brain was taken out. No trace of injury whatever was detected in the cranial contents. This man, when admitted to hospital, was collapsed and perfectly insensible. There was no paralysis, nor muscular spasm. In this state he lay for some hours, and then died. Except the intra-vertebral hemorrhage, no cause of death could be found.²

Mr. Le Gros Clark mentions a remarkable case of the same kind, which was narrated to him, but which he did not see:—

A man was violently struck on the back by a chain-cable; there were no immediate symptoms of spinal injury, but a paraplegic condition soon supervened, extending rapidly upward and destroying life by asphyxia. The theca was found distended with fluid blood, derived from a ruptured spinal artery. He likewise mentions another case: A man was injured in a collision in the tunnel, four or five miles from Brighton. He walked this distance with some difficulty into the town; and, within twenty-four hours, became entirely paraplegic. He slowly recovered, so that, at the end of two years, he was able to walk as well as before the injury. One spot on the back was always tender; and, at times, still continued so.³

The close resemblance which the symptoms that presented themselves in this case, bore to those that were observed in the preceding case, indicates that the pathological lesion was the same in both instances, namely, extravasation of blood within the spinal dura mater from ruptured spinal arteries, whereby the spinal cord was compressed.

The *symptoms* which result most frequently from this lesion are those of

¹ Loc. cit., pp. 364–366.

² Mém. de la Soc. de Chirurg. de Paris, t. iii. p. 180; also Holmes's System of Surgery, 2d ed., vol. ii. p. 300.

³ British Medical Journal, October 3, 1868.

paraplegia, coming on some little time after a violent contusion or sprain of the back, the paralysis appearing first in the legs, and extending upward with more or less rapidity, according to the nature of the case. At all events, these are the phenomena which were observed in both of the instances mentioned by Le Gros Clark, as well as in that which I have myself recorded.

Treatment.—Should the surgeon be able to make a differential diagnosis in a case where this accident has occurred, it may be advisable for him to prescribe the fluid extract of ergot in doses of thirty drops every four hours, or the acetate of lead in doses of two grains every hour or two, with a view to suppress the bleeding. In cases where the hemorrhage has ceased, it will generally be advisable to administer potassium iodide in doses of ten grains every eight hours in simple syrup, with a view to promote absorption of the effused blood. Quiet should be enjoined, and measures should be employed to prevent the occurrence of spinal meningitis and myelitis.

II. INJURIES OF THE VERTEBRAL COLUMN.

DISLOCATIONS OF THE VERTEBRÆ.

The traumatic lesions to which the several pieces of the spinal column are exposed consist, (1) of *pure dislocation*, (2) of *pure fracture*, and (3) of *dislocation combined with fracture*. Experience has shown that, leaving gunshot wounds of the vertebræ out of the account, pure dislocation occurs quite as frequently as pure fracture, and that dislocation combined with fracture is met with much oftener than either of them; and, perhaps, almost as frequently as both conjoined. For instance, Professor Porta found in 27 cases, *pure* dislocation in 7, dislocation complicated with fracture in 14, with 6 recoveries, so that there could not, by any possibility, have been more than 6 examples of *pure* fracture. Dissection was practised in 20 of the 21 fatal cases, that is, in all but one. The fracture complicating the dislocation was often so slight as not to be distinguishable until the autopsy revealed it. Again, Mr. Bryant found in 17 cases where the nature of the injury was verified by post-mortem examination at Guy's Hospital, during a period of five years while he was officiating as surgical registrar, that 6 were instances of pure dislocation, 3 of pure fracture, and 8 were examples of dislocation and fracture combined.

Clear views on this subject are of practical importance, because pure dislocations of the spinal column are, as a rule, more amenable to treatment than corresponding fractures with a like degree of displacement. In the latter cases, the spinal cord is apt to be scratched and torn by the sharp points and edges of the fracture-splinters and fragments, in addition to being compressed by the displacement of bone. The late Dr. D. S. Conant, of New York, reported a case of fracture of the twelfth dorsal and first lumbar vertebræ,¹ in which the patient lived six days, the spinal cord being divided by a splinter from the first lumbar vertebra, and not by displacement of the vertebra itself. It might well be that an apparently hopeless case of spinal dislocation could be saved by reducing the luxation, while a case of fracture involving the same part, with a similar amount of displacement of bone and paralysis of body, would not be saved by a like proceeding; and that, too,

¹ American Medical Times, 1861, pp. 359, 360.

because of the injury inflicted upon the cord by the splinters and fragments of broken bone. Moreover, in certain cases of *cervical* dislocation where the reduction proves to be difficult, although it is indispensable in order to save the patient from speedy death, the surgeon will be more likely to persevere until he accomplishes the reduction and thus frees the spinal cord from injurious compression, if his mind be clear in respect to the diagnosis, than he will if his opinion be unsettled. Many cases of this sort have already been recorded, some of which have been saved by a timely reduction of the dislocation, while others have perished from the lack of this proceeding; and more cases of the same sort will hereafter be met with. The clearness of view and accuracy of diagnosis needful for their proper treatment, are much more likely to be attained by making a separate study of vertebral dislocations, than by considering them together with vertebral fractures—that is, than by discussing the traumatic lesions of the vertebræ, *en masse*, as practised by most writers and lecturers on surgery, at the present day, in England and America—and, therefore, I shall not follow their example.

Until a recent date, *pure* dislocations of the vertebræ were held, by even the best informed surgeons, to be of very rare occurrence; and some of equal eminence positively denied that dislocation of the body of a vertebra, unattended with fracture, ever occurred at all. Among the latter, Delpsch was specially prominent. Abernethy likewise taught: “There can be no dislocation (of the vertebræ) surgically speaking—we do not take the word in its etymological sense; in surgical language, a dislocation is a displacement of bone, with a laceration of ligament unaccompanied with fracture; for if there be a fracture, it is not a dislocation; but, from their position, if one vertebra be knocked in, its articular surfaces must be broken” (South). Sir A. Cooper declared that he had never seen a pure dislocation of one vertebra upon another; but, at the same time, he admitted the possibility of its occurrence when he said: “If luxation of the spine ever does happen, it is an injury which is extremely rare.” In England, Mr. Lawrence was the first to demonstrate that vertebral dislocation, unattended by fracture, in reality did occur. He reported the following example:—

A robust porter, aged 22, while “carrying a heavy barrel on the back of his head and neck, slipped on descending some steps, and fell on the buttocks, the burden resting on the head and upper part of the neck. He was immediately deprived of sensibility in the trunk and limbs, and of all power over the voluntary muscles of these parts. When brought to the hospital he was completely insensible, and incapable of voluntary motion below the neck.” The respiratory movements were performed apparently by the diaphragm alone. Priapism was noted. On the next day “there was pain in the lower part of the neck; he could move the arms very slightly, and had a little feeling in the front and upper part of the chest.” On the third day “he experienced a tingling sensation in the hands, and was sensible to impressions on the upper part of the arms and thighs.” On the morning of the fifth day, very early, he died from asphyxia and exhaustion.

Autopsy.—“No displacement or inequality could be discovered by external examination, when the body was laid on the face. After cutting away the muscles from the back of the spine, the cartilaginous surfaces of the superior articular processes of the fifth cervical vertebra came into view. They were exposed in consequence of the inferior processes of the fourth vertebra having been completely dislocated forwards, and remaining fixed in their unnatural position. The yellow ligaments connecting the laminae of the two vertebræ [ligamenta subflava] were torn through, and the bifid apex of the fourth spinous process lay in close contact with the basis of the fifth. On the front of the column an unusual projection was observed, but the anterior longitudinal ligamentous expansion [anterior common ligament] was entire. The body of the fourth was completely detached from that of the fifth vertebra, the connecting fibro-cartilage being torn through, and the body of the former projecting by its whole depth in front of the

latter. In consequence of this displacement, the antero-posterior diameter of the vertebral canal was lessened about one-third."¹

The specimen was preserved, I believe, in the museum of St. Bartholomew's Hospital. In this case, then, there undoubtedly occurred "a displacement of bone with a laceration of ligament unaccompanied with fracture;" or, in other words, there was unquestionably a pure dislocation of the fourth cervical vertebra forward upon the fifth.

The French surgeons had already ascertained that the atlas might be luxated on the axis without fracture; and that, occasionally, a luxation of the articular process on one side (unilateral dislocation) occurred among the last five cervical vertebræ.² But these lesions were held to be of extremely rare occurrence; and, as to luxation of the bodies of the vertebræ without fracture, the possibility of such an accident was scarcely admitted. On the latter point, Boyer says: "If we examine the facts upon which a belief of the possibility of their being luxated is founded, we shall find that the posterior laminae of the vertebræ are uniformly broken, often crushed, and reduced to splinters, and that, almost always, when the body of a vertebra is luxated, the separation of its ligaments tears off a piece of the bone itself."³ Boyer has been blindly followed by most writers on spinal injuries since his day. (Ashhurst.)

In 1865, however, Professor Porta's memoir on "Dislocations of the Vertebræ" was read before the Royal Lombard Institution of Science and Letters, and was summarized in Omodei's *Annali Universali di Medicina*, whereby the chief points made in it have become widely known. This memoir is founded on 27 cases—13 in the cervical, 10 in the dorsal, and 4 in the lumbar region. No case of luxation of the occiput on the atlas, nor of the atlas on the axis is included. There were only six recoveries. Necroscopy was practised in 20 out of the 21 fatal cases. Prof. Porta asserts that dislocations of the bodies of the vertebræ, which all authors (including Morgagni) have believed to be rare, are common enough, and met with every year in hospital practice. Experiments on the spinal column removed from the body, and denuded of its muscles, show that by vigorous torsion the intervertebral cartilage and ligaments can always be torn, and this dislocation be thus produced. He combats the opinion of Boyer that the dislocation is always accompanied by fracture, and mentions seven cases in which there was no such complication. Even when fracture does accompany the luxation, the complexion of the accident is determined by the luxation and the extent of its displacement. As already stated, 14 cases were complicated with fracture—5 in the cervical, 6 in the dorsal, and 3 in the lumbar region. He regards the concomitant fracture as a phenomenon secondary to the dislocation.⁴

In 1867, Mr. Bryant published some statistics of spinal injuries,⁵ in order to show that *pure dislocation* of the vertebræ was less rare than was usually taught. During a period of five years, ending in 1858, while he officiated as surgical registrar at Guy's Hospital, 46 cases of spinal injury were admitted; and, among the 46 cases, there were 24 examples of dislocation, or of fracture, or of both combined. In 10 of them, the dislocation, or the fracture, was in the cervical region; in 14, the injury was in the dorsal region. Moreover, the nature of the lesion was verified by a post-mortem examination, in 17 instances. Of these, 6 were *pure dislocations*, 3 were *pure fractures*, and 8 were examples of *dislocation combined with fracture*, as already stated. Of the *pure disloca-*

¹ Medico-Chirurg. Trans., vol. xiii. part 2, pp. 394-397. 1827.

² Boyer's Surgery, translated by Stevens, vol. ii. pp. 230-234. New York, 1816.

³ Ibid., p. 235.

⁴ New Syd. Soc. Retrospect, 1865-1866, pp. 281-283.

⁵ Lancet, April 6.

tions, 5 occurred in the cervical and 1 in the dorsal region. The nature of the lesion was verified by a post-mortem examination in every one of the 10 cases in which a cervical vertebra was injured; and thus, pure dislocation was found, beyond question, in one-half, or 50 per cent., of the cervical cases. It was found in 2 between the fourth and fifth vertebræ of the neck; in 2 between the fifth and sixth; and in 1 between the last cervical and first dorsal vertebræ. In each of the other 5 cases of injury to the cervical portion of the spine, the lesion consisted of dislocation and fracture combined. All of the examples of *pure fracture* were found in the dorsal region. Three examples of dislocation combined with fracture were also found in this region. The instance of *pure dislocation* in the dorsal region, above mentioned, occurred between the eleventh and twelfth vertebræ. The ligaments normally connecting these vertebræ were ruptured at all the joints between them, and the body of the eleventh was thrown forward. In the remaining 7 cases of injury to the dorsal portion of the spine, there was no autopsy; but the lesions occurred about the tenth, eleventh, and twelfth vertebræ.

Professor Porta's memoir and Mr. Bryant's article mark the commencement of a new epoch in the surgical history of vertebral injuries. Some forty years before, Mr. Lawrence had demonstrated, as already mentioned, that the body of a vertebra, as well as an articular process, could be disjoined from its fellow without being attended by any fracture. They, however, went much further, and demonstrated that pure dislocations of the vertebræ were not, by any means, extremely rare lesions; that, on the contrary, they occurred about as frequently as pure fractures of the vertebræ in civil practice, and that dislocations combined with fractures were met with in the spinal column at large much oftener than either of these lesions. Mr. Bryant went further still, and showed that pure dislocations were mostly found in the cervical region, but seldom in the dorsal and lumbar regions.

In 1867, awakened interest in this neglected branch of surgery was also manifested in America, by the publication of Professor Ashhurst's instructive essay on Injuries of the Spine, with an analysis of 394 cases, the clinical histories of which he had examined. His investigations, after making due allowance for all possible errors, strongly confirm Mr. Bryant's conclusions on the last-named point. Of these 394 cases of spinal injury, 124 are reported as *pure dislocations*; 104 of them being in the cervical region, 17 in the dorsal, and only 3 in the lumbar region. Now, admitting that in some of these cases reported as pure dislocations of the vertebræ, there must also have been lesions of bone, perhaps quite limited in extent, but still constituting fractures of the vertebræ with which the dislocations were complicated, the relative proportions would not be destroyed, nor even essentially changed (it is probable), for an error of this sort is not likely to occur in a greater percentage of cases in one of the spinal regions than in another. But enough has been said to indicate that, since the days of Delpech and Abernethy, of Baron Boyer and Sir Astley Cooper, great additions have been made to the stock of our knowledge concerning this important class of spinal injuries.

Here it may be well to say that, when a vertebra is dislocated, the vertebra itself, together with the part of the spinal column resting on it, is usually moved forward upon the next vertebra below it and the rest of the column. That the displacement in vertebral dislocations is generally anterior, results from the fact that the forces causing them generally act from behind, and, having ruptured the column, they drive the upper part of it forward, in which direction this part is also drawn by its own weight and by muscular action, while the lower part remains unmoved. This, Professor Porta verified in 17 out of 26 cases, and anterior displacement was doubtless present in other instances. Hence the *upper* is usually considered to be the portion of the

spinal column that is dislocated. I shall endeavor to note any exceptions to this rule in regard to the displacement in spinal dislocations as they present themselves in the following pages.

It may likewise be well to say here that in all *pure dislocations* of the vertebræ, certainly in all of them that are bilateral or symmetrical, the intervertebral substance is torn completely through; if it were otherwise, the body of the upper vertebra could not be displaced forward nor backward, nor in any other direction upon the body of the lower vertebra.

Also, in dislocations of the cervical vertebræ complicated with fracture, the intervertebral substance is generally torn completely through, and the fracture is usually found in the spinous process, or laminae, or pedicles of the dislocated vertebra itself, but not in the body. In five successive examples of dislocation and fracture combined, Mr. Bryant found in each that the body of a vertebra was dislocated forward upon the one below; that the articular processes were displaced, or separated from each other, at their joints; and that in each there was a fracture through the spinous process or laminae of the *upper* or dislocated vertebra, the luxations having taken place at the under surfaces of the third, fourth, fifth, sixth, and seventh cervical vertebræ respectively.¹

DISLOCATIONS IN THE CERVICAL REGION.—The ginglymoid articulation between the occipital bone and the atlas, which joins the cranium to the vertebral column, and is therefore called the *articulatio capitis*, is remarkably stable and difficult to unhinge by reason (1) of the cup-shaped depressions in the transverse processes of the atlas which receive the condyles of the occipital bone; (2) by reason of the seven ligaments, some of which are very strong, that bind the atlas to the occipital bone, and (3) by reason of the narrow limits to which the motions of the joint itself are restricted. Hence, Boyer declares that there is no example of a displacement of the articular surfaces of the occiput with the vertebral column, in consequence of external violence. Even the large carnivorous animals, which prey upon the smaller, and which have occasion to make very violent movements of the head, furnish no example of this kind. In falls upon the head, in which the neck is strongly flexed, although several cervical vertebræ may be broken, the occipital bone is never luxated upon the atlas. In the bodies of persons who have died by hanging, the atlas is often found luxated upon the axis, but the occiput is never found luxated upon the atlas. Nevertheless, dislocation of the occipital bone from the atlas has been described; it is, however, extremely rare. For instance: (1) Lassus observed² the case of a man, injured by a mass of hay falling on the back of his neck, who was stunned and paralyzed, and had convulsions of the upper extremities. He lived six hours. Dislocation of the occiput from the atlas, and rupture of the vertebral artery and vein were found. (Ashhurst.) (2) Paletta described³ the case of a peasant man, aged forty, who fell head-foremost from a tree, and was paralyzed. He lived five days. Fracture of the fourth cervical vertebra and dislocation of the occiput from the atlas were found. (Ashhurst.) (3) Bouisson mentions⁴ the case of a boy, aged sixteen, who was crushed under a cart, and taken out dead. Dislocation forward of the atlas on the occiput was found. The medulla was compressed, but not crushed. (Ashhurst.) (4) A case in which dislocation of the occipital bone from the atlas and axis occurred, is noted in St. Bartholomew's Hospital Reports, vol. x. p. 313. (5) Dariste is credited⁵ with a case

¹ New Syd. Soc. Retrospect, 1867-68, pp. 275, 276.

² Pathologie Chirurgicale, t. ii.

³ Exercitationes Pathologicae.

⁴ Revue Médico-Chirurg. de Paris, t. ii.

⁵ American Journal of the Medical Sciences, O. S., vol. xxiii.

of incomplete luxation of the occiput on the atlas; cause not stated. The patient was relieved, and lived more than one year. Death resulted from other causes—tubercle of the brain. (Ashhurst.) Dariste exhibited the specimen to the Anatomical Society of Paris.

Dislocation between Occiput and Atlas—In respect to the *direction of the displacement* in dislocations at the summit of the spinal column, involving the articulation with the head, it seems that the occipital bone may be displaced backward, as well as forward, upon the atlas, for in Bouisson's case it is stated that the atlas was found dislocated forward on the occiput—that is, the occipital bone was, in reality, found to be dislocated backward on the atlas and the whole spinal column.

In regard to the *consequences* of this dislocation, whatever be its direction, it is worthy of remark that, while Bouisson's subject died immediately, Lassus's patient lived six hours, Paletta's five days, and Dariste's more than a year, death in the end resulting from another lesion. But, it is well known that any injury of the spinal cord above the origin of the phrenic nerves, that is, above the third cervical vertebra, which arrests the functions of the cord—for instance, severe compression or crushing of the cord—always causes instant death. This result, however, was noted in only one case. It is therefore evident that the degree of compression of the cord, or the amount of the displacement of the luxated bones which caused the compression, was materially less in the other cases, and very much less in two of them. This circumstance directs our attention to the fact that the foramen spinale is much wider in the atlas than it is in the other vertebræ; that the foramen magnum of the occipital bone is almost equal to it in extent; and that, therefore, a good deal of displacement of the bones may occur in disjunctings at the articulation of the head, without causing much compression of the spinal cord.

In regard to the *etiology* of the luxations which are met with at the occipito-atloid articulation, an inspection of the above-mentioned examples indicates that the application of great force, in such a way as to bend the head on the atlas far forward or backward, is requisite for their causation. This force may be directly applied, for instance, by means of a crushing weight striking on the neck, and, perhaps on the head also, as was noted in the observations of Lassus and Bouisson; or it may be indirectly applied through the cranium—for example, by falling head-foremost from a great height and striking thereon, as happened in Paletta's case. But a dislocation of the occipital bone from the atlas has never been caused, as far as known, by stretching the head and neck, however great the extending force may have been, although the experiment has often been made in executing the death-sentence on criminals by hanging. Even in those cases in which the head has been torn completely off from the trunk, from laceration of the neck by the rope, the vertebral ligaments, it is believed, have always given way at some point other than the occipito-atloid articulation—at some point where the ligaments are less able to withstand the stretching.

Spontaneous luxation, however, may occur at the occipito-atloid articulation, in consequence of the destruction or extreme weakening of its ligaments by disease. Boyer mentions an example which he had seen at La Charité, and refers to a case related by Daubenton, the specimen from which was placed in the king's cabinet. Sandifort has described five specimens, found in the museum at Leyden. Mr. Hilton has presented a very instructive case of the same sort, illustrated with two wood-cuts.¹ In these cases, the ligaments connecting the first vertebra to the occipital bone must have been destroyed by

¹ Op. cit., pp. 56-58.

ulceration; or, at least, must have become so much softened as to have quite lost their consistence and strength.

Dislocation of the atlas upon the axis very often occurs. The neck is dis-jointed at the atlo-axoid articulation more frequently than it is at the juncture of any two cervical vertebræ beside them. The considerable variety and wide extent of the movements of the head and neck, which are executed at the triple articulation between the atlas and axis, and the peculiarities in the anatomical structure thereof which enable these different movements, particularly the rotatory ones, to be performed, much increase the chances for dislocation to occur at this compound vertebral joint, notwithstanding the remarkable strength of the apparatus itself. Moreover, in almost every instance where sudden death is caused by the luxation of a cervical vertebra, the displacement of bone which crushes or fatally compresses the spinal cord is found within the spinal foramen of the atlas or axis. But, generally, in such cases, it is found within the spinal foramen of the former, and there the act of crushing or strongly compressing the spinal cord is effected by the odontoid process of the latter.

Dislocation of the first upon the second vertebra is always forward, and may be, or may not be, complicated with fracture; but, even when complicated with fracture, the dislocation is usually the more important lesion, inas-much as it generally is the bone displaced by the dislocation, which presses the cord from behind against the odontoid process in front, and thus places life in sudden peril. The special consideration, however, of fracture as a complication in such cases is, for the moment, deferred.

Dislocation of the atlas upon the axis, without fracture, that is, *pure* dislo-cation of the first upon the second vertebra, also not unfrequently occurs. It appears with probably about the same frequency as dislocation combined with fracture of the same bone. In the first variety of pure dislocation occur-ring at the atlo-axoid articulation, that is to be noticed in this place, the atlas is thrust or displaced forward because the transverse, accessory, and lateral ligaments have all been simultaneously ruptured by external violence, and nothing remains to hold the odontoid process in contact with the articular fossa, intended for its reception, on the anterior arch of the atlas. To pro-duce this variety of dislocation the expenditure of great force is obviously required. The following example will materially aid in illustrating this acci-dent:—

Lieut. J. Alman, Troop I, 4th Cavalry, was killed, March 17, 1868, in a collision between a row-boat, which was carrying him to Jefferson, Texas, and a steamboat. He was struck by the paddles of the wheel and carried under. His body was once thrown to the surface by the eddies of the water, and then sank. Every effort was made to secure his remains, but without avail, until the sixth day after the disaster, when the body, in a very advanced stage of decomposition, rose to the surface. An *autopsy* revealed a dislocation of the atlas upon the second cervical vertebra, with rupture of the transverse ligaments, and the odontoid process impinging upon the spinal marrow.¹

In this case, the strength of the odontoid process was greater than that of the transverse and other ligaments combined. Hence, when the triple articu-lation to which they belonged was subjected to a great strain, they gave way and allowed dislocation forward of the atlas to occur, with crushing of the spinal cord against the odontoid process of the axis. The strength which the odontoid process manifested in this case does not appear to have been excep-tional; for Dr. Stephen Smith, after making numerous experiments that bear on this point, comes to the following conclusions: (1) In a healthy condition

¹ Circular No. 3, S. G. O., August 17, 1871.

of parts, the odontoid process has greater strength than either the anterior arch of the atlas, or the transverse ligament. (2) The odontoid process is less liable to be fractured by external violence than the body of the axis at the insertion of the process. (3) The odontoid process is not fractured by being driven against the transverse ligament or anterior arch of the atlas.¹

Again, it appears that the ligaments of the atlo-axoid articulation may be broken in detail, as it were, or one after another, by violently turning or rotating the head to one side, and that dislocation forward of the atlas may in this way be produced. In a violent rotation of the head to one side, the alar or check ligaments of the odontoid process are put upon a stretch, and twisted around this process. The momentum of the head is opposed by these ligaments alone, and, if at this time the head be inclined to either side, one of the alar or check ligaments, more tense than the other, yields first, and thus renders the rupture of both more easy. When the alar, check, or odontoid ligaments are once broken, rupture of the transverse and other ligaments easily follows. It is not improbable that the dislocation in the following instance was produced in this manner by a powerful blow in the face:—

A man, named Carter, was killed in a brawl, on the night of July 18, 1882. The blow was planted fairly in his face by his assailant's fist. He dropped to the ground as if felled by an axe, and did not move afterward. An *autopsy* showed that death had resulted immediately from dislocation of the spinal column, and injury of the spinal cord, at the junction of the atlas and axis, the lesion being identical with that caused by hanging.²

Such a blow, planted on the man's cheek while his head was already turned in the opposite direction, might, by rotating his head with great force still further in the same direction, readily break the odontoid or check ligaments first, and then the transverse and the other ligaments successively. Owing to the skull being articulated at its base, near the middle, on the summit of the cervical portion of the vertebral column, imaginary lines drawn from the point of junction to the farthest convexities on the skull's periphery, will represent levers, which will act on the axis of motion in the cervical vertebrae, with power commensurate to their different lengths. (Shaw.) In the case just mentioned, the portion of the head intervening between the malar prominence of the cheek and the occipito-atloid articulation would constitute a lever, through which the blow on the cheek would act with greatly augmented force upon the axis of motion in the cervical vertebrae; and, in this way, the odontoid and the other ligaments belonging to the atlo-axoid articulation would be successively ruptured, and the atlas would be dislocated upon the axis, as it were, by powerfully twisting the neck by means of force applied to the face.

So, too, Louis, the famous French surgeon, in endeavoring to distinguish, among those who had died by hanging, the suicide from the victim of assassination, found that those who were merely suspended by a rope died simply from strangulation, while those who, after being swung off from the gallows, had their necks *twisted*, had also the first cervical vertebra luxated upon the second. Moreover, the hangman at Lyons having reduced the practice of his infamous profession to its elemental principles, always produced disjoining of the neck by sitting on the shoulders of the culprit, and rotating the head and bending it to one side until he heard the crack which informed him that he had effected dislocation of the atlas upon the axis. (Boyer.)

But traction (direct) of the head, especially when combined with rotation, is peculiarly dangerous in children, on account of its liability to cause luxa-

¹ Am. Journal of the Med. Sciences, October, 1871.

² New York Sun, July 22, 1882.

tion of the first vertebra upon the second. Several cases are reported where children, in turning somersaults, dislocated the first upon the second vertebra; and Marjolin states that in very young persons the odontoid process is so short that it may pass behind the transverse ligament, without rupturing the latter. (Ashhurst.) In young subjects, the odontoid process being yet incompletely developed, and the odontoid ligaments being proportionally longer and less firm, traction directly applied to the head with rotation, may stretch and break these ligaments and their accessories, so as to permit the odontoid process to pass under the transverse ligament and crush the spinal cord, without rupturing that ligament. J. L. Petit saw a child, aged 6 or 7, lifted up by a man (in order to see London, according to the vulgar saying), who took hold of the forehead and back part of the head. The child struggled, became agitated, and died. Although no anatomical examination was made, there is little doubt that the atlas was luxated upon the axis. (Boyer.)

An infant, 8 days old, was instantly killed by violence from its mother; Maschka reports that the second cervical vertebra was found dislocated.¹ This case probably belongs to the same category as those mentioned in the last paragraph; and in it, likewise, dislocation occurred between the atlas and the axis, because the odontoid process was so short, from want of development, that it passed under the transverse ligament, as soon as the odontoid or check ligaments had been ruptured.

The *etiology* of luxation at the juncture of the atlas and axis can be further illustrated by referring to 12 examples of it that are mentioned in Professor Ashhurst's tables.² Of these, it was caused, in four instances, by falling from a height and alighting on the head; in two instances, by suicidal hanging; in one instance, by the fall of a bundle of hay upon the head; in one instance, by blows on the back of the neck; in one instance, by muscular action; while in three cases, the form of the injury is not stated. It is worthy of remark that there is no mention, in Professor Ashhurst's tables, of any instance where this lesion was caused by the hanging of criminals according to law, although it is well known that this lesion is often present in such cases. The probable reason for this absence of mention is the fact that such cases are but seldom reported in the medical journals. Hospital reports, likewise, but seldom contain any examples of luxation of the atlas upon the axis, because the victims of this accident generally do not survive long enough to get into a hospital.

But, dislocation at the juncture of the first and second cervical vertebræ sometimes occurs *spontaneously*, in consequence of disease having destroyed the ligaments of the threefold articulation. I have already mentioned a remarkable example of this sort (page 284) which was recorded by Mr. Hilton.³ In such cases, the head and the atlas together fall forward; and thus the spinal cord may be crushed or strongly compressed by the latter against the odontoid process of the axis which remains fixed. In this way, Mr. Hilton's patient was almost instantly killed. Duverney met with a case in which the atlas had fallen forward so far, in consequence of the destruction by disease of the atlo-axoid ligaments, that the odontoid process was approximated to the posterior arch of the atlas by two-thirds of the diameter of its foramen spinale. (Boyer.)

Furthermore, dislocation of the atlas upon the axis, whether caused by injury or by disease, does not prove immediately fatal unless the displacement of the former be so great that its posterior arch crushes, or strongly compresses, the spinal cord against the odontoid process of the latter. In cases

¹ New Syd. Soc. Year-Book, 1859, p. 427.

² Op. cit., pp. 72-121.

³ Op. cit., pp. 61, 62.

where the displacement of bone is not so great as to seriously compress the cord, however, life may be prolonged for many hours or many days, and even recovery may take place. For example:—

A mason, aged 60,¹ fell head-foremost from a height. He suffered from shock, and there was unnatural mobility of his head. He survived the accident, however, twenty hours. An *autopsy* showed dislocation forward of the atlas on the axis; no fracture; the spinal cord was compressed by the odontoid process. (Ashhurst.) Again, a boy, aged 15,² was injured by blows on the back of the neck, but paralysis did not supervene until four months afterward. One-half of a month later still, death ensued. An *autopsy* revealed dislocation forward of the atlas, with compression of the spinal cord. (Ashhurst.) Moreover, in two cases mentioned in Professor Ashhurst's tables, where "dislocation or displacement of the atlas" was diagnosed, reduction by extension, etc., proved successful; and in one case of "dislocation of the odontoid process" recovery also is stated to have taken place.³

In the case of a female patient, aged 45, where there was at least subluxation of the atlas from disease of the atlo-axoid articulation, Mr. Hilton says: "The head was inclined to fall forward, and, indeed, she found it impossible to keep it up without artificial support of some kind. On pressing the head directly downward upon the spine, and attempting to rotate the head upon the spine, she could not bear it. She became nearly pulseless and fainted, and the limbs tremulous and agitated. We immediately placed her upon the floor of the room. I thought she was dead, but she very slowly recovered."⁴

Still, this patient, in the end, regained good health after many months of treatment, which consisted mainly in absolute rest of the spine in bed with two large half-filled bags of sand placed, one on each side of the head and neck, to prevent any lateral movement of the head, and a small, firm pillow put under the neck, to remedy the displacement of the atlas by raising the axis to the same level, thereby freeing the spinal cord from the impingement upon it of the odontoid process of the axis. The last-mentioned point in the treatment is of very great importance. Concerning it Mr. Hilton observes:—

"The patient was placed with her back flat on her bed. This position brought on extreme difficulty in her breathing. Whilst she was still in the recumbent position, and breathing with difficulty, I placed my hand underneath the neck, and lifted upward and forward that part of the spine. The sense of suffocation became at once diminished (I had observed the same circumstance before in another patient who had disease of the highest part of the spine), and I had therefore a small, firm pillow put underneath the neck, which supported it very perfectly. This is a very important fact, because I think I have known at least two persons who were destroyed in consequence of this little point not having been attended to."⁵

Considerable space has been devoted to this example because of its intrinsic value in showing what the plan of treating this lesion should be, in cases of injury where life is not immediately destroyed, as well as in cases of disease.

¹ Journal de Chirurgie, 1844.

² Revue Médico-Chirurg., t. xii.

³ The two instances, that are barely mentioned above, in which traumatic dislocation of the atlas was successfully treated by reduction, deserve additional notice: (1) A man, aged 60 (Malgaigne, Traité des Fract. et des Luxations, t. ii.), was injured by a bundle of hay falling on his head. His head was bent forward so that his chin touched the sternum, but there was no paralysis. A dislocation of the atlas was diagnosed. Malgaigne (Senior) reduced the dislocation by making extension, and the man recovered. Two years afterward his head could not be turned. (2) A lad, aged 16 (Journ. Complémentaire, t. xxxvi.), fell backward from a ladder, with a sack of flour over his head. He was unconscious, almost pulseless, and paralyzed. There was abnormal mobility of the head, and a prominence in front and to the left of the point of abnormal mobility. A displacement of the atlas was diagnosed. Ehrlich effected reduction by applying extension and pressure. The success of his efforts was marked by an audible sound. Recovery ensued.

⁴ Op. cit., pp. 56-60.

⁵ Ibid., p. 58.

Dislocation forward of the axis upon the third cervical vertebra, without fracture, carrying the atlas and the head forward with the axis, has been reported in a few instances. In the following example, where pure luxation of the second upon the third cervical vertebra was found, partial paralysis of the left arm and forearm was noted, while the lower extremities and the bladder were entirely free from paralysis; but death suddenly occurred on the fourth day:—

The case was that of a man, aged 34.¹ On the patient's admission to hospital, there were observed paralysis of the left deltoid muscle, and impaired power of supination of the left forearm, showing involvement of the left circumflex and musculo-spiral nerves. All the movements of the lower extremities, however, were perfect, and the patient had complete control over the bladder. But he became restless, and threw his limbs about; and died suddenly on the fourth day, while struggling and kicking. At the *autopsy* a dislocation of the second from the third cervical vertebra was found, with very extensive extravasation of blood behind the pharynx and œsophagus, uncomplicated with fracture. Mr. Erichsen remarks on the great rarity of the case. There were no head-symptoms, and there was also no general paralysis. Stress is laid on the absence of any hyperæsthetic line during life, as indicating that the lesion was a dislocation rather than a fracture, because the broken sharp edges of bone in a fracture would irritate the spinal nerves in contact with them, and thus cause hyperæsthesia in the tract supplied by the irritated nerve-fibres.

It is not improbable that this man's sudden death was caused by sudden compression of the spinal cord, resulting from a sudden increase in the displacement forward of the second cervical vertebra, which was occasioned by the restlessness and tossing of the patient himself. In treating such a case, confinement to bed in the recumbent posture from the outset, with a small, firm pillow placed under the neck, and a large, half-filled bag of dry sand moulded to each side of the head and neck, as recommended by Mr. Hilton in treating luxations of the upper cervical vertebræ from disease, would be of inestimable value, and would probably lead to the patient's recovery as well as prevent the occurrence of sudden death.

Another example of this accident may be briefly reported as follows:—

A man, aged 50,² fell backward from a fence and struck upon his head, sustaining thereby a dislocation of the second from the third cervical vertebra. His head was thrown back, and there was paralysis, but no pain. Attempts at reduction failed; and, in forty-eight hours, he died. (Ashhurst.)

Pure luxations at the juncture of the second and third cervical vertebræ are extremely rare; and I have found only the two examples just presented. One reason why these cases very seldom come under treatment, possibly is the fact that the vertebral displacement is very liable to cause instant death, at the time of the accident, by strongly compressing or crushing the spinal cord above the origin of the phrenic nerves. But, in the examples which do come under treatment, it may sometimes be a remedial measure of very great importance to effect a reduction of the displacement, especially if the paralysis be extending or threatening to become complete paraplegia. In such a case, the efforts at reduction should be persisted in until they achieve success.

The next case is of interest mainly because it shows that death by hanging may be attended with luxation at the juncture of the second and third cervical vertebræ, as well as with fracture of the second:—

Mahon³ found in a female criminal, on whom the death-sentence had been executed by hanging, that the axis was fractured, and that the intervertebral cartilage between the axis and the third cervical vertebra was ruptured. (Ashhurst.)

¹ Lancet, August 1, 1874. Some remarks thereon by Mr. Erichsen are also presented.

² Boston Med. and Surg. Journal, vol. x.

³ Méd. Légale, t. iii.

Dislocations of the last five cervical vertebræ (that is, of any vertebra from the third to the seventh inclusive) from violence, without fracture, frequently come under the care of surgeons. For example, of 36 fatal cases of injury of the cervical vertebræ extracted from the records of Guy's Hospital prior to 1878, 11 were examples of pure dislocation, all of them below the third cervical vertebra; and the remaining 25 were instances of dislocation combined with fracture.¹ Pure dislocation below the third cervical vertebra is therefore met with in about 30 per cent. of all the cases in which traumatic lesions of the cervical vertebræ occur; and, in the rest of them, the dislocation is generally combined with fracture.

Again, of these 11 examples of pure dislocation, 4 were found between the fourth and fifth cervical vertebræ; 2 between the fifth and sixth; 3 between the sixth and seventh; and 2 between the seventh cervical and the first dorsal vertebra. In 6 of them, the displacement was so great as to crush the spinal cord. In 5, there was no marked paralysis as a direct result of the injury, although secondary paralysis subsequently appeared, from stretching or other injury of the cord, and proved fatal. In none of them was there even the smallest trace of fracture.

Death generally ensued within seventy-two hours in those cases of cervical dislocation where the spinal cord was injured enough to cause paraplegia; and, in a majority of the instances, within forty-eight hours. For example, 28 of the 36 fatal cases observed at Guy's Hospital died in less than seventy-two hours, and 20 in less than forty-eight hours; 8 only survived the former period, and in them no symptoms of paralysis resulted immediately from the accident. (Bryant.)

In every one of these cases of cervical dislocation, the upper vertebra was thrown forward upon the lower, and the intervertebral cartilage connecting them was ruptured. In the luxations that occur among the last five cervical vertebræ, then, as well as in those that have already been described, the displaced bone carries with it the whole of that portion of the spinal column which is placed above it, no single vertebra being simultaneously dislocated from those above, as well as from those below it. When spinal symptoms result in these cases, the cord is generally found to be injured by the displaced bone; in some instances it is crushed, in others bruised, and in others merely compressed.

The following case, with the accompanying wood-cut (Fig. 859), will afford a good illustration of the disjoinings which are met with among the last five cervical vertebræ:—

Private John F., Co. B, 2d Infantry, a powerful, muscular German, aged 35, was badly hurt by falling on his head while attempting to turn a somersault, on February 10, 1866. Instead of alighting upon his feet, his head struck the earth, and he rolled over upon his side and lay motionless; face pale, respiration sighing, pulse slow and full. Examination showed that sensation and power of motion were alike wanting from the neck downward. The walls of his chest were motionless, and respiration was effected by the diaphragm alone. He moved his head freely from side to side, but could not raise it. On lifting his head from the table, so much distress ensued that the effort was abandoned, and he was turned partly upon his side, in order to examine the neck. But the examination was very unsatisfactory, for the layers of muscles and fat were so thick that the spinous processes could not be distinctly perceived, and a positive diagnosis could not be arrived at. It was clear, however, that there was an abnormal gap or depression between the spinous processes of the fourth and fifth, or the fifth and sixth, cervical vertebræ; that pressure on this depression gave slight pain; that crepitus was absent; and, that the movements of the head upon the atlas, and of the atlas upon the axis, were such as to prove that these articulations were not involved.

¹ Bryant, *Practice of Surgery*, Am. ed., 1879, pp. 201, 202.

The respiratory movements indicated that the lesion of the spinal cord was below the origin of the phrenic nerves, and the total paralysis of the upper extremities that it was situated above the origin of the brachial plexus. The patient, thenceforth, was left undisturbed. He lay perfectly supine, breathing by the diaphragm alone, suffered no pain, and was able to swallow small quantities of fluids. His pulse which immediately after the accident was 78, in two hours fell to 72. About three ounces of turbid urine were withdrawn by catheter in the evening. He sank gradually, and died forty-four hours after the accident.

Autopsy, five hours after death. Rigor mortis imperfectly established; sugillation general over posterior portion of body; ulceration over the sacrum had already commenced. The lower and back part of the neck exhibited slight tumefaction, yet sufficient to obliterate the depression which had been felt during life. The whole cervical portion of the spinal column was exposed by dissection, which revealed a dislocation forward of the fourth cervical vertebra upon the fifth. (The accompanying wood-cut, Fig. 859, clearly shows that the fourth cervical vertebra was dislocated from the fifth, and not the latter from the former, as stated in the report of the case.) The luxation was "symmetrical." There was a wide interval of one and a half inches between the spinous processes of the fourth and fifth vertebræ, which caused the depression perceived at the first examination of patient. There was no fracture of the body, pedicles, or laminae of the displaced bone, but a part of the anterior tubercle of the right transverse process of the fifth vertebra had been snapped off. The ligamenta subflava and capsular ligaments connecting the fourth and fifth vertebræ had been ruptured, as well as the attachment of the ligamentum nuchæ to these bones. The anterior and posterior common ligaments were not broken. There was a slight extravasation of blood external to the theca vertebralis, and a considerable quantity between the theca and the spinal cord. At the point of luxation, the cord was bent at an abrupt angle, and its antero-posterior diameter reduced more than one-half by compression from the laminae of the displaced fourth vertebra against the body of the fifth, and by tilting forward of the upper four vertebræ. The meninges of the cord were not torn, nor was the cord itself lacerated, which may perhaps be accounted for by the fact that the wide separation of the laminae posteriorly allowed it to bulge out in that direction, and thus escape rupture. The lungs were generally congested, the left more than the right. The posterior portions were especially engorged; but crepitation was nowhere entirely absent. The heart was slightly hypertrophied and all its cavities empty. The osteal specimen was removed and sent to the Army Medical Museum. It is represented in Fig. 859.¹

The symptoms in this case clearly indicated that there was dislocation forward of a vertebra, with much displacement, somewhat below the middle of the cervical region, without much fracture. The completeness with which the skin and all the muscles below the neck, excepting the diaphragm, were paralyzed, denotes that the spinal cord was either severed or strongly compressed by the displaced bone. The autopsy showed that the antero-posterior diameter of the cord was lessened more than one-half by displacement forward of the fourth vertebra, and that the compression of the cord thus caused was supplemented by the extravasation of considerable blood between the theca and the cord. It is not improbable that the extravasation of blood, if it did not directly occasion, hastened by at least some hours the occurrence of death, by compressing the spinal cord at and above the origin of the phrenic nerves. It should here be stated that, in vertebral dislocations and

Fig. 859.



Luxation forward of the fourth cervical vertebra upon the fifth. Spec. 549, Sect. I., A. M. M. The four upper cervical vertebræ are displaced far forward, and the axis of the vertebral column is also abruptly bent in the same direction at the place of luxation.

¹ Circular No. 3, S. G. O., August 17, 1871.

fractures, blood is often extravasated in large quantity between the theca and the cord, and that such extravasation proves to be the proximate cause of death by compressing the cord.

A case with many points of resemblance to the foregoing was treated some years ago by myself:—

A robust man, aged about 30, while driving a peddler's wagon having a very high seat, into a carriage-house having a rather low door, struck the back of his head with great force against a beam at the top of the doorway, which crushed him down into the seat. He instantly became helpless and was carried into the house. Two hours afterward I saw him; he then lay in bed on his back, with his neck bent forward and stiff, and he seemed to dread lest an attempt to raise his head should be made; he could, however, roll his head freely from side to side. His lower extremities, body, and upper extremities were completely paralyzed, both as to sensation and motion. His mind was clear, and he said he was free from suffering. He was breathing by the diaphragm alone, for all the other respiratory muscles were paralyzed. By turning his body on to the left side I was enabled to examine the back of his neck, which was thick, muscular, and somewhat swollen. The spinous processes of the fifth and sixth, or sixth and seventh cervical vertebræ (I was not quite sure which) were widely separated from each other, and the vertebræ above the point of separation were thrown forward. The abrupt bending of his neck forward, above mentioned, resulted from the wide separation of the spinous processes and laminæ behind, and the thrusting forward of the body of the dislocated vertebra and those above it. I took it for granted that some fracture was also present, but it seemed to be the dislocation alone which caused the deformity, the displacement of bone, and the compression of the spinal cord. I catheterized him, and then noticed that he had partial erection of the penis, or priapism. He was placed in a soft bed and a milk-diet allowed. The attendants were cautioned against injuring his neck while giving him food or drink. The accident happened in the afternoon.

The next morning it was observed that sensibility had partially returned to his arms, but the paralysis as to motion was still complete; in other respects his condition was unchanged. The urine was now drawn off with a catheter, and again in the evening.

The following day did not bring any signs of improvement. The urine had a strong ammoniacal odor. The bowels had not moved. The abdomen was swollen by gases in the intestines. A terebinthinate enema was administered. Catheterization twice a day was continued.

On the third morning he was much worse. His respiration was difficult, the movements being much increased in frequency, and accompanied by moist rales. His lips were becoming blue; he was tympanitic; he sank rapidly, and died asphyxiated, seventy hours after the accident. An autopsy could not be obtained.

Another case, almost the exact counterpart of the last, I once saw in consultation with the late Dr. Jenks S. Sprague, formerly president of the New York State Medical Society:—

A healthy, middle-aged farmer fell backward from the top of a loaded hay-wagon, and struck the ground with the back of his head and neck, the whole weight of his body being superimposed. He was instantly deprived of the use of all his limbs. He was picked up, in a helpless state, and carried to his home, where the writer saw him as consultant, as stated above, a few hours afterward. He was completely paralyzed both as to sensation and voluntary motion, up to the root of the neck. The head and neck were considerably inclined forward, the latter being stiff. The spinous processes and laminæ of the last two cervical vertebræ were widely separated from each other, and the sixth vertebra was dislocated forward, so far that its laminæ strongly compressed the spinal cord against the body of the seventh. The presence of fracture was suspected, although no crepitus nor movable fragments of bone could be detected. The head rotated well at the *atlo-axoid* articulation. He lay on his back and breathed by means of the diaphragm alone. Catheterization was necessary. There was priapism. His intellect was not disturbed, and he said that he was free from pain.

The symptoms and progress of this case bore so close a resemblance to those attend-

ing the last, that it is not worth while to describe them. He also died, asphyxiated, on the fourth day; autopsy not allowed.

In both of my cases, the wide gap or interval which marked the separation of the spinous processes of the two vertebræ particularly injured, the displacement forward of the upper one, and the abrupt bend in the axis of the spinal column, forward, at the point of separation between these two vertebræ, with the stiffness of the neck, denoted that the first bone above that point, together with all the cervical vertebræ resting upon it, was dislocated forward, while the rest of the spinal column remained fixed or unmoved. Although no crepitus nor fragments of broken bone could be detected, it still was supposed that some degree of fracture, perhaps but slight, was also present, inasmuch as dislocations of the cervical vertebræ are complicated by fracture in a large majority of instances. Nevertheless, it is quite possible that both dislocations were uncomplicated or pure. However this may be, it is quite clear that, in each instance, the compression of the spinal cord was caused by the displacement forward of the dislocated vertebra; and that the indication for treatment, if the cases had not been regarded as almost hopeless, would have been to free the cord from compression by putting the dislocated bone back into its natural place. In reflecting upon these cases, I have often regretted that I did not make trial of reducing the dislocation, under anæsthesia, at least in the case of the peddler, the improvement in whose symptoms on the second day indicated that the cord was not irreparably injured. On the next day, however, his symptoms were all worse, and the prognosis hopeless. Had I this case now to treat, I should, as soon as it became clear that the man would not recover under an expectant plan of treatment, that is, on the second morning after the accident, relax his muscles completely by administering an anæsthetic, and then, by carefully made extension and rotation, etc., proceed to restore the dislocated bone to its normal position. In pursuing such a course, I would be guided by the following considerations: (1) The almost absolute certainty of a fatal termination in this class of cases, within two or three days, if an expectant plan of treatment be followed. Of 36 perfectly analogous cases treated at Guy's Hospital, all died within seventy-two hours. (2) The fact that some strictly analogous cases have undoubtedly been saved by reducing the dislocation. Three examples of recovery, by means of reduction, from symmetrical dislocations occurring among the last five cervical vertebræ, that were apparently hopeless, are mentioned in Professor Ashhurst's tables. It is stated that, in one of them, the patient, a woman, was already unconscious, and her heart had nearly stopped; and, that in another, where reduction was effected forty hours after the accident, by extension, the patient had been unconscious for half an hour, that there was dyspnoea, and that death was imminent; the success of the manœuvre was indicated by an audible "snap." (3) The effort to reduce the dislocation should be made as affording the sole, and, at the same time, a not unreasonable prospect of saving the patient's life. I therefore would delay the attempt at reduction, in such extreme cases, until the symptoms denoted that the patient was rapidly going from bad to worse, as intimated above.

Dislocation of some one of the last five cervical vertebræ may be caused while bathing, by striking the back of the head upon the ground in diving, as happened in the following instances:—

A soldier, aged 25,¹ struck his head in this manner while bathing. Paralysis, etc., appeared, and dislocation of a cervical vertebra was diagnosticated. Death ensued in twenty-three days. The posterior ligament between the third and fourth cervical

¹ Am. Medical Times, vol. vii.

vertebræ was found to be ruptured. (Ashhurst.) A similar accident happened to a sailor, whose case is reported by J. Roux. He plunged head-foremost into the sea for the purpose of bathing, and was injured by striking against a sail which had been sunk to prevent the attack of sharks; on the fourth day he died. In both of these cases the dislocation was doubtless caused by forcibly bending the head and neck forward upon the chest. This summer (1882), while I write, several instances of cervical dislocation, caused by diving in shallow water and striking the head against the ground, have been reported at Coney Island, where, this season, multitudes greater than ever are said to bathe.

Etiology.—The examples presented above, as well as many cases on record which have not been presented, show that symmetrical dislocations of the vertebræ, at the middle and lower part of the cervical region, are generally caused by powerful flexion of the neck upon the chest, from falling upon or striking against the back of the head with great force, “though traction and rotation conjoined have occasioned them.” There is also one case on record in which the mode of injury is said to have been a blow, struck upon the neck of a drunken man, aged 30, which caused him to fall. Reduction was effected by extension, under chloroform, on the tenth day, by Dr. Ayres, of Brooklyn, N. Y., and the patient recovered. Dupuytren, too, reports a fatal case, in which dislocation forward of the fifth cervical vertebra, with fracture of the sixth, was produced directly by a plank striking on the neck.

Among the *predisposing* causes of dislocation in the cervical region are: (1) the remarkable mobility of the cervical vertebræ upon each other; (2) the obliquely horizontal position of their articular processes; and, (3) the nearly horizontal direction of their spinous processes. Moreover, these anatomical peculiarities likewise strongly favor the occurrence of dislocation, without fracture, in the cervical region.

Fracture of the sternum is not unfrequently associated with the injuries of the spinal column which are caused by the forcible bending forward of the head. Mr. Bryant says that it was found in four instances among the fifty-six fatal cases of spinal dislocation and fracture which were observed at Guy's Hospital.

Diagnosis.—The symptoms and course of symmetrical or bilateral dislocations of the vertebræ, when they occur at the middle or lower part of the neck, are clearly set forth by the examples that have just been presented.

1. Whenever the bones which enter into the formation of the vertebral joints are dislocated, deformity ensues, for the same reason that it does when other bones are dislocated, for instance, those of the extremities; and although the cervical vertebræ are covered by thick layers of muscular tissue, etc., the deformity which results from a bilateral dislocation of these bones can always be perceived, if the examination be conducted with sufficient care and skill. Of course, the deformity will vary according to the direction and extent of the displacement of bone. But, generally, the displaced bone, together with all the vertebræ surmounting it, is thrown forward in such cases. Oftentimes the spinous process of the dislocated vertebra is separated from the spinous process of the next vertebra below it, or that from which it is dislocated, by a distance of one and a half or even two inches; and, in consequence of this separation, a wide gap, with a corresponding depression of the soft parts, may be felt between them. In such cases, the head is usually thrust forward, and the axis of the spinal column also bends abruptly forward at the place of injury. At the same time, the mobility of the vertebral joints that are involved is more or less completely destroyed, and all attempts to produce motion in them cause corresponding pains. Not unfrequently, in cases where the cervical vertebræ are injured, it is concluded that certain joints belonging thereto are not luxated, from the fact that their mobility is not impaired; for

instance, it is shown by nodding and rotating the patient's head that the luxation (if any) is not at the atlo-axoid articulation, but somewhere below it. Oftentimes, too, the body of the disjoined vertebra can be felt bulging forward into the pharynx, and this point in the examination is an important one to look after. As a rule, in these cases, the abnormal position of the salient points of the dislocated bone, as well as the rigidity and painfulness of the injured articulations, can readily be detected by a manual examination. But if there be preternatural mobility, and especially if there be crepitus felt in connection with the displaced bone, it will be strong evidence that fracture is present as well as luxation.

2. If, in cases of cervical dislocation, the spinal cord be not compressed by the displaced bone, nor otherwise injured, there will at first be no paralysis, and no subjective symptoms whatever, excepting the immobility, soreness, and painfulness of the disjoined articulations. In such cases, however, spinal paralysis may subsequently appear, and death ensue. Several instances of this sort are on record. For example:—

Caussé¹ gives the case of a man who injured his neck by falling from a chariot on to the wheel. There was at first no paralysis; only stiffness of neck and pain on bending it. On the third day, however, in turning his head he felt a crack, and became paralyzed. Death ensued, and complete forward dislocation of the fifth cervical vertebra was found. (Ashhurst.) It is not improbable that, in this case, the luxation was incomplete at first, but became complete on the third day, in consequence of the accident sustained in turning his head.

Dupuytren likewise reports the case of a mason, aged 49, who fell backward down stairs, striking his head on a step; a bag of plaster came upon his breast. In consequence, his head was thrown forward and to the right, his neck was stiff, and the spinous processes of the fourth and fifth cervical vertebrae could not be felt, while their transverse processes were abnormally prominent. At first there was no paralysis, but afterwards it came on, and in ten hours death ensued. The fifth cervical vertebra was found displaced forward with fracture of its processes, and the spinal cord was divided. It is not improbable that in this case, too, the luxation at first was incomplete, and the spinal cord being not compressed there was no paralysis; but, in a few hours, it became complete, because the cord was divided, perhaps from injudicious attempts to examine or to remove the patient, and then paralysis immediately appeared. The paralysis must have increased rapidly, for death soon ensued.

In analogous cases, when spinal paralysis does not appear, recovery may take place. For example: Greenhow² reports the case of a female, aged 25, who fell thirty feet, striking the head. She sustained dislocation of three or four upper cervical vertebrae, and was insensible for three days, *but had no paralysis*. There was a scalp wound and fractured clavicle. She was under observation fourteen days, and recovered, but the deformity remained.

Again, Professor Hamilton³ mentions the case of a man, aged 40, who was thrown from a wagon, striking the back of his neck. He was stunned for several hours; then paralysis came on. However, he did not die; but, after nine months, the spinous process of the seventh cervical vertebra was still displaced to the left side. His head also was bent forward and his neck was stiff; he could walk a few steps, but with fatigue; he likewise had pain in the legs, etc. (Ashhurst.)

But if, in cases of cervical dislocation, the spinal cord be slightly compressed, or slightly bruised, or slightly torn, there will from the outset be paralysis of the parts to which the injured nerve-filaments are distributed. Several cases belonging to this category, whose issue was fatal, are on record. It is not necessary to reproduce them.

Finally, if the spinal cord be crushed or strongly compressed at the middle

¹ Mémoire Médico-légale, etc.

² Lancet, 1851.

³ Op. cit.

or lower part of the cervical region by a dislocated or a fractured vertebra, there will be paralysis embracing the whole of the body excepting the head and neck, priapism, retention of urine and feces, flushed face, calor mordicans, diaphragmatic breathing, dyspnoea, and in a short time death from asphyxia. Several cases in point have already been presented. For diagnosing the lesion itself, however, the paralysis in these cases is of no practical value, inasmuch as it may result from concussion of the spinal cord, and from the effusion of blood, or of the products of inflammatory action upon the cord, as well as from the displacements of bone which attend vertebral dislocations. But, for *prognostic* purposes the paralysis in such cases is of great value.

The signs, then, by which a bilateral dislocation of a cervical vertebra in the middle or lower part of the neck may be recognized, consist of the physical evidences of the displacement itself, the absence of the symptoms which characterize fractures, such as crepitus and unnatural mobility of the vertebra in question, or of some part thereof. But, inasmuch as vertebral fracture may occur without being attended by crepitus or suspicious mobility, especially if the fracture be but slight, we never can positively assert of any case of cervical dislocation, during life, that it is entirely uncomplicated by fracture. Thus, it appears, that while the diagnosis of vertebral dislocation (bilateral) at the middle or lower part of the neck is, in general, not very difficult, the diagnosis of slight fracture simultaneously involving the same bones, is often impossible during life. This, however, is not a matter of much practical importance, since the perils of the case depend upon the injury of the spinal cord, which results mainly from the displacement of bone that is due to the dislocation; and to this point the attention should first be directed in treating the case.

Prognosis.—Luxations of the vertebræ are more dangerous to life than the luxations of other bones, on account of the great risk there is that the spinal cord and spinal nerves will be directly or indirectly injured thereby, and that spinal paralysis will ensue. Luxations of the cervical vertebræ are more dangerous than luxations of the dorsal and lumbar vertebræ, on account of the great risk there is that the chief respiratory muscles, the serratus posticus superior and inferior, the serratus magnus anticus, the diaphragm, etc., will be paralyzed thereby, and that death from asphyxia will immediately ensue.

When the spinal cord is crushed or strongly compressed *above* the third cervical vertebra, in cases of spinal dislocation or fracture, life is instantly destroyed, because the chief respiratory nerves, to wit, the two phrenic, the four thoracic, and the respiratory branches of the intercostal nerves, from having their several origins in the cord below that point, instantly cease to act (as do all the spinal nerves that originate in or pass off from the cord below the same point), and therefore the muscles to which they are distributed instantly cease to perform the respiratory movements.

When the spinal cord is crushed or strongly compressed *below* the origin of the phrenic and long thoracic nerves, in cases of cervical dislocation or fracture, death will generally be deferred for some little time, although the whole body, excepting the head and neck, will be paralyzed in respect to sensation and voluntary motion. In such cases, the respiratory function is maintained by the action of the serratus magnus anticus and the diaphragm alone.

In cases of dislocation or fracture of the spinal column above the third cervical vertebra, experience has shown that life is often instantaneously destroyed. In cases of dislocation or fracture below the third cervical vertebra and above the first dorsal, where the cord is so much injured that there is motor and sensory paralysis of nearly the whole body excepting the head and neck, and the respiratory process is maintained solely by the diaphragm and serratus magnus, life is seldom prolonged more than 72 hours, and, as a rule,

not above 48 hours. In one of Dupuytren's cases, that has just been mentioned, death ensued in 10 hours; and Professor Hamilton refers to an instance of complete dislocation of the fifth cervical vertebra, without fracture, in which death occurred in 2 hours. But, on the other hand, Mr. Bryant mentions the case of a gentleman, aged 29, with complete paralysis below the fifth cervical vertebra, caused by a fall upon the neck, who was still alive over six years afterward, and breathing by the diaphragm alone. Mr. Hilton, likewise, has recorded the case of a man who lived for fourteen years completely paralyzed from the neck downward, after sustaining a fracture of the fifth and sixth cervical vertebræ. Such exceptions to the rule, however, are very rare.

The prognosis in cases of dislocation or fracture of the cervical vertebræ must be mainly determined by the seat of the lesion, and the amount of damage which the spinal cord has received. Usually, the nearer the seat of the injury is to the respiratory centre, the greater is the danger to life. When, however, no paralysis appears in the case, it will generally end in recovery, for luxations of the vertebræ unattended by lesions of the spinal cord do not seem to be any more hazardous to life than luxations of other bones of a corresponding size. It should not be forgotten, however, that where there is no paralysis at first, it may supervene in a few hours in consequence of the displacement of bone becoming increased, or from the extravasation of blood between the theca and the cord, or from the occurrence of traumatic inflammation of the cord or its membranes. Several illustrative cases have already been mentioned. In the following instance, paralysis and death resulted from traumatic meningo-myelitis:—

Simon¹ relates the case of a woman, aged 18, who fell eleven or twelve feet and was stunned. She walked home, three or four miles, and resumed work for eleven days. Then pain, fever, etc., appeared; and, on the sixteenth day, paralysis. Delirium, "jumping of legs," etc., followed, and, in eighteen days, death ensued. Fracture of the seventh cervical vertebra was found, and the spinal canal filled with pus. (Ashhurst.)

Certain symptoms are considered of peculiarly evil omen in cases of spinal injury. They are a steady increase in the extent or degree of the paralysis, dysphagia, dyspnoea, flushed face, and alteration of the vital temperature. These symptoms, however, and their import, will be discussed further on in this article. Here, I will only mention a single case reported by Brodie,² wherein the cervical portion of the spine was injured, and there was paraplegia with diaphragmatic breathing. A thermometer placed between the thighs showed the body-heat to be 111° Fahr. Death ensued in twenty-two hours. Displacement of the fifth from the sixth cervical vertebra was found, and laceration of the cord with effusion of blood in the spinal canal.

The *proximate cause of death* in dislocations and fractures of the lower cervical vertebræ generally consists in a creeping upward of certain morbid processes which have been set up in the spinal membranes, or in the substance of the spinal cord, opposite the vertebral lesion, from the place of primary injury to the roots of the phrenic nerves (above the third cervical vertebra), whereupon these nerves cease to act, the diaphragm ceases to contract, and death from asphyxia ensues. In some cases the morbid process consists in extravasation of blood between the theca vertebralis and the cord, which spreads upward until it compresses the cord at and above the third cervical vertebra, as happened in the case of a soldier mentioned above, who dislocated his neck in vainly attempting to turn a somersault. In other cases, the

¹ Proc. Lond. Path. Soc., vol. vi.

² Med.-Chir. Trans., vol. xx.

morbid process consists of an ascending spinal meningitis. In still others, it consists of an ascending traumatic myelitis, and this class is probably a numerous one. People who are fatally injured in the cervical part of the spine, as a rule, do not live long enough to get sacral and gluteal eschars, or bed-sores, nor for vesical and renal disease to occur in consequence of the rachidian lesions.

Treatment of Cervical Dislocations.—Here, it may be well to state again, that in all pure dislocations of the cervical vertebræ, certainly in all that are bilateral or symmetrical, the intervertebral substance is torn through, and the upper vertebra is displaced forward from the lower; that in dislocations and fractures combined, of the last five or six cervical vertebræ, the intervertebral substance is also torn through, and the upper vertebra displaced forward from the lower; and that, in such cases, the fracture is generally found in the spinous process, the laminae, or the pedicles of the dislocated vertebra, but not in its body. Thus, it is seen that the displacement is strictly analogous, in cases of dislocation combined with fracture, to what it is in pure dislocation, and that the treatment of the former should be substantially the same as the treatment of the latter.

Moreover, in dislocations and fractures of the spinal column, it is not the lesions of the vertebræ, *per se*, which disable and kill, as much as it is the displacement of bone, and the extravasation of blood between the theca and the cord, or into the cord itself, and the consecutive inflammation of cord and membranes, that may attend these lesions; for, by the above-named consequences of spinal injury, the substance of the spinal cord is directly torn, or bruised, or compressed, or disorganized, so that the spinal nervous functions in the segment of the cord below the place of injury may cease entirely to be performed, and the parts dependent thereon for innervation become completely paralyzed. It is, then, the displacements of bone, the intra-spinal extravasations of blood, and the inflammations of the cord and its membranes that attend these lesions, which the surgeon must chiefly consider in conducting the treatment of these cases.

When a person receives, in any way, a dislocation or a fracture of the neck, or of any other part of the spinal column, the first thing of importance to do is to effect the person's removal to hospital or home without producing additional injury. To this end, the patient should be placed in an extended position, on the flat of the back, upon a board, settee, or stretcher, and in that way carried in as nearly a fixed or immovable position as possible. If the lesion be situated above the third cervical vertebra, a small, firmly rolled wad of clothing should generally be placed under the neck in order to keep it raised up, and thus prevent the head from falling forward and dragging with it the spinal cord against the odontoid process of the axis. In such cases, too, the head should be kept steady, and prevented from rolling from side to side.

At the first examination, the surgeon should make the diagnosis as complete and accurate as possible, particularly in regard to the distortion or deformity of the injured parts and the displacement of the injured bones, so that future examinations on these points may be avoided. Should the lesion prove to be a dislocation, whether it be pure or attended by fracture, the question will immediately arise whether it ought to be reduced or not; that is, whether the principal indication in the treatment of dislocations in general ought to be fulfilled in treating vertebral dislocations, or not. On this point, which is nearly the main point in the treatment of such cases, the opinions of surgeons have been unhappily divided. Mr. Erichsen says, "Reduction has been effected [with success] in a sufficient number of cases

of this kind to justify the proceeding being adopted when the danger is imminent."¹ Dupuytren, on the other hand, affirmed that such attempts were very dangerous, and that he had often known patients to perish while the extension was being made (Hamilton); from which the legitimate inference would follow that reduction was, in such cases, a proceeding too hazardous to be admissible. I have, however, serious doubts as to Dupuytren's assertion being well-founded, for I do not find any case whatever reported in detail, which Dupuytren could personally have known, wherein the patient perished while extension was being made. No instance of the sort is mentioned among the 394 cases which are embraced in Professor Ashhurst's tables, nor elsewhere, as far as I am informed. Moreover, an inspection of Professor Ashhurst's tables clearly shows that "in the treatment of dislocations in the cervical region, the mortality has been nearly four times greater when constitutional or general treatment has been relied on exclusively, than when attempts have been made to reduce the dislocation by extension, rotation, etc."² An inspection of the same tables also shows that in the treatment of dislocations, in the whole spinal column, "the proportion of deaths has been almost three times as large when general treatment has been exclusively used as when extension has been employed. The results of those cases which have survived have also been, as a rule, more satisfactory after extension than without it."³ I have already mentioned several instances in which reduction was successfully employed in the treatment of cervical dislocations, in some of which recovery would otherwise have been utterly hopeless.

It seems to me that the inference is fairly warranted, from the foregoing considerations, that extension (combined, of course, with rotation or pressure as required) should be employed in every case of spinal dislocation, or of spinal fracture with dislocation, where the spinal functions are disturbed. When the diagnosis is not clear, it will be better to adopt this mode of treatment than to reject it, and I should be disposed to try it in every case where either shortening or marked angular displacement was found. (Ashhurst.) It seems to me, also, that in recent years the current of surgical opinion has, with justice, strongly set in favor of treating spinal dislocations, those with as well as those without fracture, by reducing them. Professor Porta, after carefully analyzing twenty-seven cases in point, comes to the conclusion that the first indication in the treatment of vertebral dislocations as in that of other dislocations, is to reduce them. Mr. Bryant (1878) says: "I have seen several cases in which marked relief was afforded by this course, and the records of surgery contain many more. Practised with discretion, extension of the spine is doubtless a valuable means of treatment."⁴ Whenever it is applicable, the best plan of effecting reduction consists in making extension and counter-extension by the gradual traction of assistants, whilst the surgeon endeavors to effect manual replacement. Generally the patient's muscles should be kept relaxed by anæsthetics during the operation. In all cervical cases where the dislocation is disposed to return, extension should be continued for some days after the operation, by means of a weight of about three pounds attached to the patient's head with strips of plaster, and a band to suspend it from the head of the bed. By so doing recovery might have been effected in a case mentioned by Malgaigne:—

A man was injured by a weight falling eight or ten feet, upon his neck. There was no paralysis, but the injured part of the neck was stiff, and moving it caused great pain. Delirium appeared on the third day; and, in five days after the accident, the man died.

¹ Science and Art of Surgery, p. 293, Am. ed. 1854.

³ Ibid., p. 66.

² Op. cit., p. 64.

⁴ Op. cit., p. 204.

Incomplete luxation with fracture of a cervical vertebra was found. It had been reduced, but the displacement had been reproduced, as the autopsy showed.

Mention should not be omitted of a recent case, reported by Dr. Landon Carter Gray, of Brooklyn, N. Y., in which a dislocated third cervical vertebra was successfully reduced, after four months' malposition:—

A boy, aged 15,¹ injured his neck by falling on his head in a vain attempt to turn a somersault. For thirteen weeks after the dislocation, there was only a difficulty in deglutition. Then, the phenomena came fast and many. First, a vesical paresis; next, a numbness of the upper extremity; then, a numbness of the right leg; then, a motor paralysis of both upper and lower extremities; and finally, when he came under treatment, there was found, though the relative dates of the appearance could not be ascertained, a paresis of the left face, tactile anæsthesia of the left upper and lower extremities, an occasional tremor, exaggerated tendon-reflex (although there had been no hasty micturition), and contractures of certain muscles of the neck and shoulders.

On the back of the neck, over the third vertebra, a projection about as large as a pigeon's egg was found. Pressure upon it caused some pain around the point of pressure, but none was felt at the front or side of the neck. The spinous process of the third vertebra deviated markedly to the right. By inserting a finger into the mouth, horizontally backward on a level with the upper surface of the tongue, a distinct depression could be felt in the posterior pharyngeal wall, corresponding to the third cervical vertebra. In order to effect reduction, the boy was laid flat on his back on the table, and etherized until all his muscles were well relaxed. Grasping the head by one hand placed upon the occiput and the other on the brow, both hands being covered by those of an assistant, and counter-extension being firmly maintained, extension was steadily made upward to what was deemed a proper degree, and then the head was slowly and cautiously rotated from left to right. It was necessary to make this rotation three several times before the bone went into place, each rotation, however, effecting evident improvement, although no tendinous snap was heard at any time. But go into place it did, and without the manifestation of any dangerous symptom.

All the morbid phenomena immediately disappeared; and although they returned somewhat after a relaxation following violent emotion, a second reduction caused a permanent cure.

The formidable nature of the spinal lesion, and the happy issue of the operative treatment, render this case a very instructive one to the surgical student; and the clearness and brevity with which the symptoms and the operative procedures are set forth, must prove equally attractive. Moreover, this case shows that dislocations of the cervical vertebræ, even when the displacement of bone is not sufficient to seriously compress the spinal cord, are always accidents of considerable importance, because of the deformity and debility of the injured part which always result; but, more especially, because of the morbid action, not unfrequently inflammatory, in the spinal meninges and in the spinal cord itself, which may ensue. An ascending myelitis sometimes, perhaps often, has this origin.

Several additional cases of symmetrical luxation of the cervical vertebræ, more or less complete, which have been successfully treated by reduction, also require brief mention in this place: (1) The late Dr. James R. Wood, of New York,² had a case of partial dislocation of a cervical vertebra, occurring in a child; reduction was effected, and recovery followed. (Ashhurst.) (2) A sailor, aged 46,³ fell forward on the right side of his head, and sustained a dislocation of the fifth and sixth cervical vertebræ [with fracture?]. There was pain, crepitus, and partial paralysis. The luxation was reduced by extension and rotation, and the paralysis instantly disappeared. (Ashhurst.)

¹ *Annals of Anat. and Surg.*, February, 1882; *Am. Journ. Med. Sciences*, April, 1882, pp. 590, 591.

² *Gross's System of Surgery*, vol. ii.

³ *Eve, Surgical Cases.*

(3) A soldier¹ fell from a horse; he was stunned, and had a cervical vertebra dislocated; mobility of head was noted. Reduction was effected by extension and manipulation. He could walk again in three days, and recovered in eight days. (Ashhurst.) (4) A male child, aged $3\frac{1}{2}$ years,² was injured by another child jumping on his back. He fell and had the third or fourth cervical vertebra dislocated, but no paralysis. The luxation was reduced by extension, and recovery ensued. (Ashhurst.) (5) Dr. J. Flögel³ reports a case in which a subluxation of the cervical vertebræ was successfully reduced.

But, perhaps, the most suggestive example of recovery, by means of reduction, from an apparently hopeless dislocation of a cervical vertebra, is one to which I have barely alluded; it certainly deserves further mention. Hickerman, of Ohio, found in the case of a girl one of the vertebræ dislocated, causing a prominence in the back part of the pharynx, opposite the fourth and fifth cervical vertebræ, and almost completely suspending respiration and the action of the heart. He seized the head of the patient under his left arm and thus made extension, while with the index finger of his right hand he made pressure upon the projection in the pharynx. In about one minute the bone receded under the pressure, and immediately the respiration became natural. Recovery was complete.⁴ As already stated, there are several similar cases on record.

In striking contrast with these excellent results achieved by reduction, is the fact that among the 394 cases contained in Professor Ashhurst's tables, no mention is made of even one case of bilateral or symmetrical dislocation of a cervical vertebra, attended with paraplegia from compression of the spinal cord by the displaced bone, in which recovery took place under the expectant treatment, and but few in which death was long deferred.

But the restoration of a cervical vertebra, when luxated, to its normal position, is seldom easy, generally difficult, and sometimes almost impossible to accomplish, as the following examples will help to show:—

Gaitskill⁵ is the authority for a case of complete bilateral dislocation of the seventh cervical vertebra, attended by paralysis, which in the upper extremities was only partial. The efforts at reduction failed and the patient died. Mention has also been made on one of the preceding pages of a case of luxation of the second cervical vertebra from the third, reported by Spencer,⁶ in which the attempt at reduction likewise failed, and in which, after forty-eight hours, the man died. (Ashhurst.)

These two cases show that the surgeon who attempts to reduce luxations of the cervical vertebræ, must expect to encounter great difficulties at times, and should be prepared to overcome them; this he can generally do by persevering sufficiently in appropriate and well-directed efforts at reduction, while the muscles of the patient are completely relaxed by the inhalation of chloroform or ether.

Having reduced the dislocation, and taken adequate measures (above mentioned) to prevent its recurrence, as well as to provide against the falling forward of the patient's head in such a way as to drag the spinal cord against the odontoid process of the axis, by placing a small, firm pillow under the neck, while the patient lies flat on his back and extended in bed, the fulfilment of the second indication for treatment must next be attended to, which consists in moderating the inflammatory reaction at the injured joints, and preventing its spread to the spinal membranes and the spinal cord itself. Two examples have already been presented on the authority of Mr. Simon and M. Malgaigne, which go far to show that the spread, in such cases, of traumatic inflammation from the injured joints to the spinal meninges and the spinal

¹ Journal de Desault, t. iii.

² Journ. der Chirurgie, 1822, Bd. iii.

³ Wien. med. Halle, 1864, S. 147; New Syd. Soc. Year-Book, 1864, p. 280.

⁴ Hamilton, Princ. and Pract. of Surgery, p. 315.

⁵ London Repository, vol. xv.

⁶ Boston Medical and Surgical Journal, vol. x.

marrow, is no idle dream. Among the best means to fulfil the second indication, is to keep the injured joints as nearly immovable as possible, by applying a bag half-filled with sand close to each side of the head and neck, continuously day and night, so as to entirely prevent any lateral or rotatory motion of the parts. The patient should be supplied with food and drink while in the supine position, and without raising his head. Not unfrequently the application of leeches and cold lotions may be advisable. This plan of treatment should be continued until the cure is complete. Potassium iodide may oftentimes be administered with advantage in order to promote the absorption of inflammatory effusions and of blood from the spinal canal. The diet should be nourishing and easy to assimilate. Pain should be subdued and sleep secured by administering opium or morphia.

The condition of the back must be daily examined in order to forestall the occurrence of bed-sores. The parts must be kept dry and clean. Pressure must be removed from the salient points as far as possible, which can best be done by placing the patient on a water-bed. The condition of the bladder should be cared for from the outset. Retention of urine is almost certain to exist, for a time, and over-distension of the viscus is very detrimental. Catheterization should be performed with extreme care at least twice a day. If the urine become offensive, the bladder should be washed out daily with a weak solution of borax or boracic acid. The bowels should be moved by enemata rather than by purgatives. When incontinence of urine, or of feces, or of both, exists, the greatest attention must constantly be paid in order to keep the parts clean and dry. The frequent application of a spirit lotion, containing two per cent. of carbolic acid, to the parts, often proves useful.

In cases where the paralysis begins in the lower extremities, some hours after the accident, and steadily rises higher and higher, should the surgeon conclude the cause thereof to be the extravasation of blood (hemorrhage) occurring within the theca vertebralis, he might be justified in exhibiting the fluid extract of ergot, in full doses, and the acetate of lead and opium, as hæmostatics.

Unilateral Dislocations of the Cervical Vertebrae.—Hitherto, the symmetrical or bilateral luxations of the cervical vertebrae only have claimed our attention; but, now, the unilateral ones must be considered. They essentially consist in the displacement of the inferior articular process on one side of a cervical vertebra, from the corresponding superior articular process of the vertebra which lies next below; and they cause the victim's face to be turned toward the side opposite to that on which the luxation is situated. Many examples of this lesion have occurred, and a considerable number have been recorded. Twenty-nine cases are mentioned in Professor Ashhurst's tables. Desault related, in his lectures, the case of a lawyer, who produced this luxation, while sitting in his office with his back to the door, by turning his head suddenly round to see who was coming in. Chopart showed a young man, aged 24, who sustained a similar lesion from turning his head too far round; his face was turned to the left, and his chin ever afterward rested upon the left shoulder. (Boyer.) The following is an excellent example in which the deformity was removed with success by reducing the luxation:—

Maxson, of Geneva, N. Y., relates the case of a young girl, aged about 9 years, who had a dislocation of the right oblique process of the fifth or sixth cervical vertebra, caused by turning her head suddenly round while at play. At first, she complained only of inability to straighten the neck, and she became faint whenever she was moved. About forty-eight hours after the accident, her mother attempted to turn her head slightly, and a severe convulsion ensued. Soon after that, Dr. Maxson saw her, and could distinctly feel the displacement of the transverse process. He grasped her

head with both hands, and turned it gently in the same direction as that to which it was already inclined, namely, toward the left shoulder, in order if possible to disengage the process; then lifting or extending the head, he carefully rotated it in the opposite direction, that is, toward the right side, and the reduction was accomplished. Her recovery was speedy and complete.¹

Etiology.—In 23 of the 29 examples of this lesion that are mentioned in Professor Ashhurst's tables, the mode of injury was as follows: Turning the head quickly round, 6 instances; falling on to the head, 9; a fall striking on the neck, 2; a bundle slipped on the shoulder, 2; a fall in running, 1; direct violence, 1; being thrown against a wall, 1; tumbling heels over head on a bed, by a boy 8 or 9 years old, 1. In 6 cases the mode of injury is not stated. Thus, it appears that unilateral luxation of the cervical vertebræ is often caused, directly, by voluntary action of the muscles in turning the head suddenly to one side, as well as by blows and falls upon the neck itself; and that it also is often caused, indirectly, by falling upon the head, and by other forms of external violence, especially if they produce both rotation of the head and inclination of it to one side, as well as flexion.

Symptoms and Course.—The phenomena and consequences of this lesion may be best described by briefly presenting another example:—

M. Parisot² was called to a woman, aged 59, who had fallen from a load of hay, and found her condition as follows, thirty-six hours after the accident: The face was inclined to the right, and her chin rested a little external to the sterno-clavicular articulation of that side. The cervical region was concave on the right side, the heads of the sterno-cleido-mastoid muscle being relaxed; on the left side it was convex, and the lateral muscles were tense. The spinous processes could be felt, but without any projection. The head and neck were fixed immovably, and any attempt at motion caused great pain. The patient could not raise her head at all. Her face was congested, and the jugular veins were turgid; there was slight exophthalmos, and her respiration was becoming difficult. The right arm was paralyzed as to motion, and its sensibility was obtuse; there were also "pins and needles," and cold sensations at the ends of the fingers. The left arm was freely moved, but "pins and needles" were likewise felt therein. All the symptoms were aggravated by any attempt to raise the head. The position of the head had been unchanged since the accident; but the subjective symptoms had come on gradually, and were increasing. There was no loss of innervation in the lower part of the body. The diagnosis was unilateral dislocation of the fifth from the sixth cervical vertebra, on the right side.

The patient was placed sitting on the floor; the shoulders and legs fixed; the operator, standing behind, seized the lower jaw with both hands, the thumbs abutting on the mastoid processes, and raised the head gradually, then turned it briskly inward. A crack was heard; the patient immediately experienced great relief, and tried to turn her head around, but the paralysis had not disappeared. She was placed in bed, with her head extended by means of a weight of two kilogrammes [about $4\frac{1}{2}$ lbs.] suspended from a band fastened around the jaw; leeches and cold lotions were also applied. Next day, the paralysis of the arm had disappeared; in seventeen days, the pricking sensations were gone, and the patient recovered.

This case, take it all in all, is a not unfair representative of a rather numerous class of cases, in which unilateral dislocations of the cervical vertebræ have occurred. The stiffness, soreness, pain, and immobility of the neck, with the face turned away from the dislocated side, the peculiar distortion exhibited by the neck itself, the paralysis of one upper extremity, attended with other symptoms of nervous disorder, more dangerous in character and constantly increasing in severity, all of which were promptly relieved by restoring the luxated vertebra to its normal position, are phenomena that have

¹ Hamilton, op. cit., p. 315.

² Gaz. Hebdomadaire, 24 Nov. 1865; New Syd. Soc. Bienn. Retrospect, 1865-66, p. 283.

been observed in many other instances of this lesion that have been recorded. In several cases, too, dysphagia has been present; and, in one instance, the dislocated vertebra was found to cause a projection into the pharynx. In another case, paralysis of the upper extremities, convulsions, and hiccough were present, but they disappeared on reducing the dislocation, and recovery ensued. In but one instance is it stated that there was no weakness of the limbs. More or less paralysis, however, was noted in almost all the examples of this lesion which are mentioned in Professor Ashhurst's tables. While, in some of them, the paralysis was but slight, or quite limited in extent, and did not appear until some hours after the accident, in others, it was extensive, appeared instantly, and increased rapidly, so that death ensued in a few hours if reduction was not effected; in one case, where paralysis with dysphagia instantly appeared, death ensued in six hours, and, on dissection, incomplete unilateral dislocation of a cervical vertebra was found; in another case, where the accident instantly caused paralysis, death ensued in thirty-six hours under expectant treatment, and, on autopsy, unilateral dislocation of a cervical vertebra was found; in still another case, where death ensued in thirty-six hours, beside the dislocation, serous effusion on the arachnoid was found. In a case where paralysis, with congestion of the neck and face, was noted, death ensued in fifty-seven hours, and unilateral dislocation of the fifth from the sixth cervical vertebra was found, with rupture of the intervertebral cartilage, and compression of the spinal cord by the displaced bone.

Diagnosis.—The recognition of unilateral luxations of the cervical vertebræ, when complete, is generally not difficult; certainly it is much less difficult than that of bilateral or symmetrical dislocations of these bones. The symptoms which characterize this lesion are the twisting of the neck, and the fixed position of the face turned more or less completely round toward the opposite shoulder, perceptible immediately after the accident; the immobility, with the abnormal lateral curvature, of the neck itself; the abnormal position of the transverse process belonging to the luxated side of the misplaced vertebra; and the tenseness of the muscles on one side of the neck combined with relaxation of those on its other side. Besides, the functions of the spinal cord or spinal nerves are, in general, more or less disturbed by the displaced bone, and, consequently, there is oftentimes observed in such cases paralysis of one or both of the upper extremities, with dysphagia, and sometimes also paralysis of the lower extremities, or paraplegia.

Prognosis.—The probability of a favorable issue is usually much greater in a case of unilateral dislocation of a cervical vertebra than it is in a case of bilateral dislocation of the same vertebra; for, in the former instance, the spinal cord usually sustains much less injury than in the latter. Moreover, unilateral dislocation of these bones is complicated with fracture much less frequently than bilateral or symmetrical dislocation. At all events, the statistics show that the prognosis is much more favorable if only one of the articular processes of a cervical vertebra be luxated, than it is when both are displaced. For example, among the twenty-nine cases of unilateral dislocation which are mentioned in Professor Ashhurst's tables, there were twenty-one recoveries and only eight deaths. Furthermore, it is very instructive to note that, of the twenty-one recoveries, fifteen appear to have been achieved by reducing the dislocation, and four without attempting to reduce it, while in two instances the treatment is not stated; and that, among the eight deaths, there was only one case in which reduction was employed, and that in this case the autopsy showed that the dislocation had been reproduced.

The symptoms of peculiarly evil import are, a steady increase of the area in which paralysis is noted, dysphagia, the advent of difficult breathing, with turgescence of the veins of the neck and face, and the appearance of exoph-

thamos from impending suffocation. In such cases, if the spinal cord be not promptly relieved from pressure by reducing the dislocation—that is, if the cause of the morbid phenomena be not promptly removed—death will speedily ensue. In some cases, however, death does not occur until the lapse of many days. In at least one instance on record, the paralysis came on gradually, and death ensued in twelve days. In another instance, the paralysis did not begin until several hours after the accident, but it gradually increased, and death ensued in forty days.

Treatment.—The first indication in the treatment of unilateral luxations of the cervical vertebræ, no doubt, is to reduce the luxation. In no case can the deformity resulting from the luxation be removed, unless this indication be first fulfilled; and, in most cases, recovery from this accident cannot take place, unless the dislocated bone be seasonably restored to its normal position. As already intimated, reduction was employed in sixteen of the twenty-nine cases of this lesion, mentioned in Professor Ashhurst's tables, and it proved successful in all but one of the sixteen; in the solitary instance of failure, an autopsy showed that the dislocation had been reproduced. In no one of the eight fatal cases was a reduction of the dislocation permanently effected.

Moreover, the paralysis was *instantly* removed by reduction in many of the successful cases. The motions of the head and neck, too, were instantly restored by reduction in several of them. Likewise, the accomplishment of reduction was attended by an audible sound in several instances.

Concerning the method by which extension and rotation are to be applied in order to reduce the dislocation, Mr. Erichsen says: "In these cases I have known reduction effected by the surgeon placing his knees against the patient's shoulders, drawing on the head, and then turning it into position, the return being attended by a distinct snap."¹ For other methods of applying extension, etc., in these cases, the reader is referred to the examples of the accident, already presented.

To prevent a recurrence of the dislocation, it may be advisable to apply a collar of stiff pasteboard to the neck, for eight or ten days, as practised by Malgaigne and others; or to make permanent extension by means of a weight of two or three pounds attached to the head by means of a band and strips of adhesive plaster, as practised by M. Parisot.

To avert inflammation of the injured vertebral joints, spinal membranes, and spinal cord, rest upon the back in bed, with a small firm pillow placed under the neck, and a half-filled bag of sand fitted to each side of the head and neck to prevent any lateral movement thereof, are always necessary. Not unfrequently, leeches and cold compresses should also be applied to the injured part. The risks arising from consecutive inflammation are well illustrated by Dr. Reyburn's case of unilateral dislocation of the fifth cervical vertebra, in which, though reduction was effected, death, caused by abscess of the spinal cord, followed fourteen days subsequently.² Pain should be moved and sleep procured by giving morphia or opium.

Boyer rejected all efforts to reduce the dislocation in these cases, and quoted Petit-Radel's celebrated case to illustrate the danger of such efforts. But, as Malgaigne has shown, the case of Petit-Radel was not at all such as represented by Boyer; and the fact that in his case the efforts at reduction caused sudden death, proved nothing but that the efforts were unskilfully made by an incompetent person. (Ashhurst.) In that case the transverse ligament of the atlas was ruptured by the efforts at reduction, and the spinal cord was pressed forward against the odontoid process of the axis, with an instantly fatal result.

¹ Op. cit., p. 293.

² Am. Journ. of the Med. Sciences, July, 1871, p. 110.

The various kinds of cervical dislocation enumerated above are of great importance: (1) Because they constitute the sole lesions in about one-half of all the cases of vertebral injury which occur in civil life; (2) Because they are very deadly and often end very quickly; and (3) Because there is ground for hope that with improved methods of treatment their fatality may be considerably diminished.

DISLOCATIONS IN THE DORSAL AND LUMBAR REGIONS.—Dislocations of the vertebræ unattended by fracture are comparatively rare in the dorsal and lumbar regions. To illustrate this point, I will again state that, in 394 cases of spinal injury collected by Professor Ashhurst, only 17 examples of pure dislocation are reported as having occurred in the dorsal region, and but 3 in the lumbar region, while 104 cases of uncomplicated dislocation are credited to the cervical region. Again, of 56 fatal cases of spinal fracture and dislocation observed at Guy's Hospital, in which there were autopsies, 36 occurred in the cervical region (11 thereof being examples of pure dislocation, and the remaining 25 being instances of dislocation combined with fracture), 18 occurred in the dorsal region, and 2 in the lumbar (Bryant); but only two or three of the dorsal and lumbar cases, at the utmost, were examples of pure dislocation. The comparatively great infrequency of pure dislocations in the dorsal and lumbar regions is explicable: (1) by the fact that in traumatic spinal lesions of all sorts the cervical region is affected much oftener than both the other regions combined; and (2) by the way in which the articular processes of the dorsal and lumbar vertebræ are locked together, and by the extreme obliquity of the dorsal spinous processes, the consequence whereof is, as a rule, that at least some one or more of them is broken when a dislocation occurs in these regions. Luxations unattended by fracture are, therefore, quite exceptional in the dorsal and lumbar spine.

Etiology.—Dislocations of the dorsal and lumbar vertebræ are always due, directly or indirectly, to the application of external force; muscular action is never their chief cause. They are often produced by heavy falls from high places upon the back, shoulders, or buttocks; and, in such cases, the dislocation is, in the first-mentioned instance, directly, and, in the last two instances, indirectly occasioned, as a rule. Dorsal and lumbar dislocations, too, are not unfrequently caused, directly, by heavy blows upon the back and loins. For example, in 20 cases of dorsal or lumbar dislocation collected by myself, the lesion was caused by falling from high places, *e. g.*, from trees, from the windows and upper floors of houses, etc., in 8 instances; by falling down fourteen or fifteen steps in 1 instance; and, by falling upon the buttocks in 1 instance. Also, the lesion was caused by a blow on the back from a ton-weight, in 1 instance; by being struck on the back by a falling door, in 1 instance; by the fall of a scaffold-pole, in 1 instance; by being struck by falling timber on the shoulders, in 1 instance, and on the loins, in 1 instance; by the running of a carriage-wheel against the back, in 1 instance; by being struck on the back by a falling wall, in 1 instance; by the fall of a mass of chalk, in 1 instance; and, by striking the back against a beam in driving through an archway, in 2 instances. In each of the 10 cases, first mentioned, the luxation was caused by a heavy fall; and, in each of the remaining 10 cases, it was produced by a heavy blow on the back.

To illustrate dorsal luxation, the following case is in point:—

A man,¹ from falling down through five hatchways, received a dislocation of the sixth from the seventh dorsal vertebra, and was brought to the Brooklyn City Hospital. "No other injury was sustained. He presents all the symptoms of this lamentable

¹ Medical Record, p. 145, vol. ix. 1874.

accident, but has now been lying upon a water-bed for ninety days, and, to all appearances, is in a far better condition than he was one month ago. The patient is kept partly under the influence of morphia."

The following example, from being more fully reported, is much more instructive: A man, aged 21,¹ fell from a chestnut tree, October 4, 1871, a distance of some twenty-five or thirty feet, striking the ground with his shoulders and back. When picked up he was insensible. On recovering consciousness, he complained of severe pain in the back, shooting round into the hypogastrium and left groin. About two hours after the accident, Dr. Simpson found him lying partially on his right side, with knees drawn up and almost immovable. His back was slightly bruised and scratched, and presented a deformity indicating apparently a displacement forward of the vertebræ at the lumbo-dorsal junction; sensation in lower extremities diminished, but not obliterated; intense pain in back and in abdomen. Cold applications to the patient's back were ordered, and that he should be kept as quiet as possible; forty drops of liq. opii comp. every two hours, during the night. Next morning, Dr. Hasbrouck saw the patient in consultation. He recognized the partial dislocation of the last dorsal vertebra, but doubted the propriety of attempting to reduce it. He suggested, however, that potassium iodide, grs. v, repeated every four hours, should be added to the treatment.

Urine was passed by the patient without assistance on the night succeeding the injury. After that, catheterization had to be practised twice daily, for the next ten days, when voluntary micturition, with some straining, was re-established. There was constipation, which was not relieved by enemata, nor by purgatives *per orem*, until a hardened mass of feces in the rectum had been broken down by a finger introduced for the purpose. After twelve days, the bowels became regular. All the symptoms now began to improve regularly, excepting the deformity of the back, which increased much in extent. In about three weeks after the accident, the patient began to sit up in bed; and, four or five weeks later, to walk around the house, with the aid of a cane. During the fall and early winter, his back continued quite weak. In January, 1872, he had a brace fitted for the support of his back. March 26, 1872, he commenced work again at his trade, that of a mason. With the artificial support furnished by the brace, he feels as well, he says, as he did before the accident.

These two cases illustrate very well, not only the etiology and symptomatology of dorsal luxations, but likewise some important points in the treatment of these lesions. The patient first mentioned, derived much benefit from the water-bed upon which he had been lying for three months, when his case was reported, and from the prolonged use of enough morphia to keep him free from all pain, and to procure for him sufficient sleep. Opium administered in this way, to such patients, generally exerts a happy influence in preventing the occurrence of inflammatory complications in the spinal membranes and spinal cord, as well as in sustaining the patient's strength.

In the case last mentioned, the lesion, that is, the luxation forward of the twelfth dorsal upon the first lumbar vertebra, was caused, indirectly, by falling from a great height upon the shoulders and back. There was, for a time, insensibility from cerebral concussion. The forward displacement of the twelfth dorsal vertebra was cognizable by inspection and by manual examination; and there was incomplete paralysis of the parts below the spinal lesion. The symptoms and consequences of a vertebral dislocation were therefore clearly present; but great pain in the injured portion of the spinal column, and in the parts of the abdomen to which the spinal nerves involved in the lesion were distributed, was also observed. It was subdued by administering the opium solution in large doses and at short intervals (gtt. xl every two hours). Opium or morphia, when exhibited in full doses, is one of the most efficient agents we possess for allaying inflammatory excitement, especially in fibrous and serous membranes. Cold applications to the injured

¹ American Journal of the Medical Sciences, April, 1873, pp. 502, 503.

parts of the back were made, and absolute quietude was enjoined. Besides the opium, potassium iodide, 5 grains every four hours, was given internally. Thus, it will be perceived, that strong measures were adopted from the outset to allay any inflammation of the spinal membranes or the spinal cord which might threaten to follow the injury. To these antiphlogistic measures I attribute most of the success which was obtained in the treatment of this case. The non-employment of extension and counter-extension was evidently a mistake; for, had they been continuously applied for two or three weeks, the displacement of bone would not have increased, as actually happened, and the bladder would not have become paralyzed on the day after the accident. The excellent results which were obtained, in this case, by obviating the tendency to inflammation in the bruised and strained spinal membranes and spinal cord, by employing appropriate treatment internally as well as externally, should teach us to do likewise in all similar cases. That there is a real need for so doing, in such cases, the following observations will prove:—

A man, aged 40, was admitted to the Saint André Hospital, at Bordeaux,¹ with severe injury of the back. Mobility of the eleventh dorsal spinous process was detected. Temporary loss of consciousness from shock occurred. Then severe pain in the seat of the injury, which was near the origin of the eleventh dorsal nerves, was complained of. The parts supplied by the sacral and lumbar plexuses of nerves were paralyzed, and voluntary motion of the lower extremities was abolished. Anæsthesia of the lower extremities, and of the abdominal wall as high as the umbilicus, existed, with exaggerated reflex motility in the lower extremities. There was priapism, with retention of urine and feces, and tympanites, from vesical and intestinal paralysis. The pulse rose to 112; the breathing became diaphragmatic and difficult; and, on the eleventh day, death occurred. *Dissection* revealed fracture of the lamina of the eleventh dorsal vertebra, with dislocation of its body in front of the twelfth, contusion of the cord, and ascending myelitis. Here, then, a contusion of the spinal cord arising from a dislocation with fracture of the spinal column, eventuated in a traumatic inflammation of the spinal cord, which caused death by spreading upward until it involved the roots of the phrenic nerves, and thus suppressed the respiratory movements; and the fatal issue of this case could have been prevented, only by averting the consecutive inflammation of the spinal cord.

Bryant² reports the case of a laborer, aged 33, injured by timber falling on his shoulders. At first, there was loss of sensation, but not of motion; afterward, loss of motion, but return of sensation; finally, loss of both. In ten days death ensued. Dislocation forward of the eleventh dorsal vertebra, with fracture of the twelfth, was found; and the spinal cord was disorganized. (Ashhurst.) In cases such as this, the disorganization of the spinal cord which directly precedes, and is the proximate cause of death, is always due to inflammatory action; and well directed efforts to subdue it should always be made, by appropriate treatment, both general and local.

Robert³ mentions the case of a laborer, aged 25, who was injured in the back by a scaffold-pole falling on him. There was paralysis (paraplegia), etc., noted, but no deformity. In eleven days, however, he died. Dislocation of the fifth from the sixth dorsal vertebra was found; and the spinal cord was diffuent. This case clearly belongs to the same category as the last two, and in it an ascending myelitis of a destructive character also resulted from the injury, and caused death.

Charles Bell⁴ relates the case of a coal-wagoner, thrown from his cart while drunk, striking upon his neck and shoulders. He complained of a stiff neck, could not stand alone, and dragged his legs when supported; but when lying in bed, no paralysis appeared. Between the shoulders, at the root of the neck, there was swelling and ecchymosis; and in the loins acute pain. Leeches were applied to the swelling. On the

¹ Pousson et Lalesque, *Revue Mensuelle*, Juillet, 1880; *Lond. Med. Record*, Jan. 15, 1881.

² *Guy's Hospital Reports*, 3d S., vol. v.

³ *Half-Yearly Abstract of Med. Science*, 1854.

⁴ *Surg. Observations*, Part ii., p. 145.

eighth day convulsions occurred, and were followed by mania. On the eleventh day paralysis appeared, which afterward began to pass away. On the twentieth day death ensued. *Dissection* revealed diastasis of the seventh cervical from the first dorsal vertebra; the intervertebral cartilage had disappeared from suppurative inflammation, and purulent matter had dropped to the bottom of the spinal sheath (theca vertebralis). Outside of the injured vertebræ a large abscess was found. In this case the vertebral lesion had given rise to a destructive inflammation of the intervertebral cartilage and the formation of much pus, together with a suppurative inflammation of the spinal meninges; the latter condition, unless arrested by timely treatment, necessarily proves fatal.

Charles Bell¹ reports the case of a plasterer, aged 25, who fell forty feet, striking his back against a stone step. Depression between the spinous processes of the lower dorsal vertebræ was observed, but no paralysis. He had acute pain in the back. On the third day he was delirious, threw himself out of bed, etc. On the fifth day he had to be tied in bed, and, on the same day, he died. *Dissection* showed fracture of the body and spinous process of the eleventh dorsal vertebra; the spinal cord was not compressed by the fracture; but greenish pus was found between the cord and the theca vertebralis, and there was effusion on the brain. (Ashhurst.) From the vertebral fracture there evidently arose in this case traumatic cerebro-spinal meningitis, of a suppurative character, which caused death. It is not probable that this inflammation could have been successfully combated without the aid of local blood-letting by leeches or cups, and the continuous application of an ice-bag or an iced poultice, with opium and morphia in large doses, and potassium iodide, as well as absolute quietude of the injured and inflamed parts.

Dupuytren² mentions a case which, during life, was supposed to be concussion of the spinal cord only; there was partial paralysis and sloughing; but, in the end, death ensued. *Dissection* revealed fracture of the tenth dorsal vertebra; blood-clots and meningitis opposite the ninth, tenth, and eleventh dorsal vertebræ. (Ashhurst.) Besides the spinal fracture and the spinal meningitis, the autopsy in this case revealed an effusion of blood between the cord and theca vertebralis. Such hemorrhages are frequent concomitants of the vertebral fractures and dislocations that occur in the dorsal and lumbar regions, as well as in those that occur in the cervical region.

Dr. C. A. Lee³ reports the case of a man, aged 48, injured by falling from a building across a plank. At first, he was stunned; and, afterward, very restless. On the next day paralysis appeared; and a projection in the middle of the back was noted. In five weeks death ensued. *Dissection* showed fracture of two dorsal vertebræ; the spinal cord was softened; and purulent matter was found in the vertebral canal. Here, too, spinal meningitis arose from fracture of the dorsal vertebræ, and was attended by the formation of pus. Obviously, such cases cannot be conducted to a successful issue, unless the occurrence of traumatic spinal meningitis in them be seasonably recognized, and the disorder itself combated by appropriate treatment.

Many additional examples of spinal meningitis and myelitis arising from spinal dislocations and fractures might be cited from the records. But, enough of them already have been presented to clearly show that, in every case of vertebral dislocation or fracture, where life continues, there exists a strong tendency for consecutive inflammation of the spinal membranes and cord to ensue; that, not unfrequently, traumatic meningitis or myelitis is the proximate cause of death, in such cases; and that the surgeon should, in all such cases, employ remedial measures of known efficacy, from the outset, in order to prevent the traumatic irritation of the spinal membranes and cord from rising to the grade of inflammatory action.

Symptoms and Prognosis.—When dislocation of the joints of a vertebra occurs in the dorsal or lumbar region, it is always attended by functional

¹ Ibid., p. 138.

² Diseases and Injuries of Bones. London, Sydenham Society, 1847.

³ American Journ. Med. Sciences, O. S. vol. xvii.

disturbance and displacement of the bones which form the compound articulation; and, generally, by ecchymosis. Inasmuch as the vertebral joints are more superficial in the dorsal and lumbar regions than they are in the cervical, the displacement of bone is more easily recognized by sight and touch in the former regions than it is in the latter. The symptoms by which luxations of the dorsal and lumbar vertebræ may be known, are the deformity and the disturbances of function which arise from the displacement of the luxated bones, and the ecchymosis. The displacement is often denoted by a projection backward of the lower vertebra. Sometimes a distinct gap can be felt between the dislocated vertebra and the bone next below it. Frequently their spinous processes are found to be separated by a considerable interval. Occasionally they are so widely separated that three fingers can be laid between them. Oftentimes the patient has severe pain in the injured part of the back. Not unfrequently the patient has also severe pain in parts far removed from the back, that is, in the parts where the spinal nerves that pass through the inter-vertebral notches at the place of injury, are distributed or have their terminal extremities. Should the spinal cord be much injured, there will be paralysis both sensory and motor (paraplegia) of all the parts supplied by spinal nerves that issue from the segment of the cord which lies below the lesion. Paralysis of the bladder will be denoted by retention or by incontinence of urine; paralysis of the intestines by retention or by incontinence of feces, and by tympanites. The area of lost sensibility usually corresponds very closely to that of the motor paralysis, because the anterior and posterior roots of the spinal nerves emerge from the cord on the same level. The following example will serve to show how profound and durable the sensory paralysis, as well as the motor, may be:—

Dr. W. D. Purple¹ reports the case of a man, aged 22, injured from being struck by the limb of a tree. There was dislocation of the fifth and sixth dorsal vertebræ with permanent as well as complete paralysis, both sensory and motor, of the lower part of the body, or paraplegia. Six years afterward he had both thighs amputated high up, because the paralyzed limbs were useless appendages. He felt nothing whatever during the operation, although no anæsthetic was employed. Seven years after the injury he died from other causes; no autopsy.

But, in many cases of vertebral dislocation or fracture with injury of the cord, marked *hyperæsthesia* with *intense pain* is noted *just above* the paralyzed region.² The last-named symptoms, however, will be discussed in connection with the subject of *Traumatic Myelitis*, as it is the disorder from which they arise.

Should the ganglionic nerves which lie along the spinal column, on each side thereof, and in close relation thereto, be much injured, especially in the cervical region, there may arise therefrom, as well as from injuries of the spinal cord, vaso-motor disturbances, denoted by alterations of the pulse, by flushing of the face, and by a considerable increase or diminution of the body-heat. Paralysis of the vaso-motor nerves, thus induced, lessens the blood-pressure in the arteries, and modifies the character of the pulse accordingly. With each blood-wave, the condition of feeble pressure passes suddenly into a condition of forcible pressure at the moment of the ventricular systole, and suddenly reverts to the former condition, for the blood flows too readily through the paralyzed capillaries from the arterial into the venous system. MM. Pousson and Lalesque found this forcible impulse or peculiar sensation of a strong pulse to be most marked in large arteries, *e. g.*, the femoral and the abdominal aorta. The sphygmographic tracing presents, with pulse-

¹ New York Journal of Med., 1853.

² Med. News and Abstract, March, 1881, pp. 179, 180.

modifications of this kind, a very high and vertically ascending line, and a concave and prolonged descending line.¹

In regard to changes of the body-heat in consequence of spinal injuries, I will briefly mention a few examples:—

Dr. T. G. Mcrton² found in a case where the fifth, sixth, and seventh cervical vertebræ were fractured, with paralysis, etc., that the temperature two hours after the accident was 102° Fahr; in eleven days the patient died. Professor William Pepper³ relates a case in which there were fractures of the first and fourth cervical vertebræ, with anterior luxation of the latter, as well as compression of the spinal cord, death ensuing 24½ hours after the injury; the whole cutaneous surface was much warmer than normal, and a thermometer in the axilla registered 108.5° Fahr. at the moment of death; the cheeks were brightly flushed, and very hot; but the pupils were about normal. Mr. Shaw⁴ relates the case of a drayman, aged 35, injured by a bag of hops falling upon his head and shoulders, in which there were fracture of the fourth dorsal vertebra, paralysis, priapism, and a temperature of 103–106° Fahr. (Ashhurst.) Brodie's case of spinal injury, in which the mercury rose to 111° Fahr., has already been mentioned. A number of cases are on record in which "calor mordicans" was noted. On the other hand, Dr. A. Niden⁵ reports the case of a man, aged 60, injured by falling down fourteen or fifteen steps, in which there were temporary loss of consciousness, complete paralysis of lower extremities, bladder, and greater part of trunk, progressive lowering of the temperature, and pulse of a remarkable character. He died on the eleventh day after the accident, with a temperature of 80.6° Fahr. He remained conscious until his temperature was 81° Fahr. and his pulse 30. The *autopsy* showed luxation without fracture of the first dorsal vertebra, with compression of the spinal cord. A somewhat similar case was under the care of Mr. Hutchinson, at the London Hospital. There was complete paralysis as high as an inch above the nipples, with marked priapism; temperature 98°. The next day the pulse was noted at 36 and small; in the evening, the temperature in the rectum was only 95.8°, in the distended penis 93°. The patient's cheeks and lips were of very good color, remarkably so; while to the touch they seemed as cold as those of a corpse. But he did not complain of feeling cold. The temperature sank to 95°, and, on the sixth day, he died. The temperature did not rise after death. The autopsy showed fracture of the fifth cervical vertebra, and severe injury of the cord.⁶ Something like a "flushed face" appears to have been noted in this case, although the temperature was much below the normal.

No clear explanation of cases such as this has yet been made. But paralysis of the vaso-motor nerves may arise from lesions of the spinal cord, as well as from injuries of the ganglionic chain of nerves, or the great sympathetic. "Flushing of the face," in cases of spinal injury, is usually attended by lachrymation and contracted pupils, and is clearly due to vaso-motor paralysis.

Mr. Erichsen says that he has seen unequivocal instances of continued low temperature of the body, taken in the mouth and axilla, in cases of spinal concussion—as low as 92° or 93° F., and continuing for many months from 2° to 3° F. below the normal.⁷ He also refers to Dr. Niden's case in which the first dorsal vertebra was dislocated, mentioned above. "More commonly the low temperature is confined to the extremities, especially the feet, which are sensibly colder than other parts of the body. Often the feet are as low as 80° to 85° F., and will remain so for very long periods of time."⁸

The *prognosis* in cases where the dorsal or lumbar vertebræ are injured is usually much less unfavorable than it is in cases where the cervical vertebræ

¹ *Ibid.*, p. 181.

² Proceedings of the Pathological Soc. of Philadelphia, vol. i.

³ American Journal Med. Sciences, April, 1867, pp. 437, 438.

⁴ Holmes's System of Surgery, vol. ii.

⁵ New Syd. Soc. Retrospect, 1873–4, pp. 351, 352.

⁷ On Concussion of the Spine, etc., 1882, p. 65.

⁶ Clin. Soc. Trans., vol. vi. 1873.

⁸ *Ibid.*

have sustained similar lesions; and, as a rule, the further the seat of injury is removed from the respiratory centres, the more favorable is the prognosis. In dorsal and lumbar dislocations and fractures, without intra-spinal hemorrhage, the chief sources of danger to life are the occurrence of spinal meningitis, of ascending myelitis, of trophic lesions such as sacral and gluteal eschars or bed-sores, and of vesical or renal inflammation. The appearance of either of these complications greatly increases the gravity of every case. There are some symptoms, however, which are especially bad prognostics. Among them may be mentioned persistent elevation or depression of the body-temperature, flushing of the face, great frequency or infrequency of the pulse, early appearing and rapidly spreading sacral or gluteal eschars or acute bed-sores, incontinence of urine and feces succeeding retention, enlargement of the paralyzed area in an upward direction and increase of the paralytic symptoms, especially when they are progressive, diaphragmatic breathing, and dyspnœa. Incontinence of feces and urine succeeds retention in these cases, because the sphincter muscles have become paralyzed; and this circumstance denotes that the nerve centres upon which their action depends have become affected. Progressive, upward extension and deepening of the paralysis, generally indicate progressive, upward disorganization of the cord. Diaphragmatic breathing coming on some days after the accident, is a most unfavorable symptom, and generally denotes that the compression or disorganization of the spinal cord has attained so high a point that the diaphragm alone of all the respiratory muscles remains unparalyzed. Dyspnœa occurring in this connection usually indicates that the aëration of the blood is quite imperfect, and that the induction of fatal coma in consequence thereof may be at hand. Priapism is generally a dangerous symptom, but not necessarily a fatal one; for there are cases on record of recovery from spinal injury where this symptom had existed.

The progressive diminution of paralysis, in these cases, is a most favorable symptom. The return of motor power is not unfrequently attended by involuntary contractions and twitchings of the muscles; these symptoms, however, are not to be considered unfavorable at this stage, although they are supposed by Brodie, and probably with justice, to indicate compression or mechanical irritation of the spinal cord when they attend an earlier stage.

Treatment.—In no case of dislocation of the dorsal or lumbar vertebræ, however clear the symptoms of the dislocation may be, can it be asserted with absolute certainty during life that no fracture is present. While pure dislocations of these vertebræ are quite rare, dislocations combined with fracture are quite common in the dorsal and lumbar regions; but the treatment of both forms of injury should be conducted on substantially the same plan. The want of a strictly exact diagnosis in this regard is, therefore, not as essential to the therapeutics of dorsal and lumbar dislocations as it is in those of the cervical region.

The condition of the injured parts in dorsal and lumbar dislocations, as well as in cervical, is usually as follows: The muscular and connective tissue around the displacement is extensively lacerated and infiltrated with blood; the intervertebral disk or ligament is torn through at the seat of displacement, so as to allow the body of the upper vertebra to be thrown forward from that of the lower; the anterior and posterior common ligaments are much stretched and extensively detached; the ligamenta subflava and the capsular ligaments are lacerated; the laminae, or certain of the vertebral processes, are fractured; the theca vertebralis is stained with blood, bruised, stretched, and perhaps somewhat torn; the spinal canal contains more or less blood; while the spinal cord is ecchymosed and abruptly bent, and sometimes presents a compressed

appearance, or is even divided completely, at a point corresponding to the displacement of the vertebræ.

The victim of this accident should be taken up from the place where he has fallen, and removed to hospital or home with great care to avoid increasing the displacement of the luxated bone and the injury of the spinal cord, as already described for cases of cervical dislocation. The patient should be placed in bed; and then, for reasons already stated under the head of treatment of cervical dislocations, which, however, are equally applicable in cases of dorsal or lumbar dislocation, the replacement of the luxated bone into its normal position should be attempted. But before proceeding further with the discussion, I will briefly describe the various methods which have been successfully employed, in practice, for accomplishing this result in the dorsal and lumbar regions; and, probably, I cannot do it in a better way than by presenting abstracts of the cases themselves.

Malgaigne¹ mentions a case of Melchiori's, in which a carter was injured in the dorsal region by a wheel running against him. There was backward dislocation of the eighth dorsal vertebra, and paralysis. Reduction was effected by position in bed. Recovery ensued in six months. Slight deformity, however, remained. (Ashhurst.) When it is found that, by placing the patient upon his back in bed, the displaced vertebra is restored to its normal position, with the aid, perhaps, of moderate extension and some pressure laterally applied, a good hair mattress or a water-bed (the latter is much preferable) should be arranged for his reception, and he must be kept lying upon it, as nearly immovable as possible, until firm union has taken place.

Rudiger² is credited with the case of a musketeer, who was struck on the back by a falling wall, and sustained dislocation backward and to the right side of the twelfth dorsal vertebra. Reduction was effected by position (on the belly) in bed; extension and pressure were continued for fifteen days. In six weeks recovery ensued. (Ashhurst.) This case shows that the surgeon, by consulting his ingenuity, may sometimes, perhaps not unfrequently, make the patient's posture in bed materially assist in reducing a vertebral dislocation of the back or loins, when the dorsal decubitus utterly fails to do it. Moreover, while the patient lies with the back uppermost, a free opportunity is afforded for the efficient application of local treatment, to prevent the development of consecutive spinal meningitis and myelitis.

Parker³ mentions the case of a man who was struck on the back by a falling door, and sustained dislocation of the last dorsal on the first lumbar vertebra, with slight fracture. There were paralysis, priapism, etc. Reduction was accomplished, with an audible sound, by making extension and counter-extension, under chloroform. After several months the patient recovered, and, when discharged, could walk with a cane. (Ashhurst.) It is important to note that, notwithstanding there was priapism in this case, recovery ensued. The dislocation was reduced by making extension and counter-extension, under chloroform. I think the best plan for the surgeon to pursue, on failing to reduce such a dislocation by the patient's position in bed, would generally be to relax the muscles completely by anæsthesia, and, then, to effect the reduction by means of extension and counter-extension steadily made by his assistants, with lateral pressure locally applied by himself.

Brodie⁴ refers to the case of a man, injured by a mass of chalk falling upon him. The first lumbar vertebra projected backward over the last dorsal. The dislocation was reduced with some difficulty by Mr. Hardwicke. The reduction was attended by a "jerk or snap." The patient was relieved; but, after two or three years, partial paralysis still remained. (Ashhurst.) No doubt, in this case likewise, the reduction was accomplished by making extension and counter-extension.

Smith⁵ mentions a case of Schmucker's, in which a soldier was injured by a wall falling on his back. He was stunned; there was displacement backward of the last

¹ *Traité des Fract. et des Luxat.*, t. ii.

² *New York Journal of Med.*, 1852.

³ *New York Journal of Med.*, 1852.

⁴ *Desault, Journ. de Chir.*, t. iii.

⁵ *Med.-Chir. Trans.*, vol. xx. p. 157.

dorsal and first lumbar vertebræ, and dyspnœa. The displacement was reduced by extension and pressure. In six weeks the man recovered. (Ashhurst.)

Crowfoot reports¹ the case of a coachman, aged 42, who in driving under an arch struck the back of his neck against a beam. There was displacement forward of the ninth dorsal vertebra, and of the tenth, backward, with paralysis. He was treated by continuous extension with success, and resumed his occupation in one year; slight deformity, however, remained. (Ashhurst.)

After reduction, should the displacement reappear, and particularly if the dislocated bone should manifest a disposition to slip out of place again, it will be advisable to make the extension continuous, which may be done in several different ways; but, probably, with the least amount of trouble, by raising the head of the bedstead upon blocks so as to make of the bed itself an inclined plane sloping downward to the foot, when, by attaching with a suitable band the upper part of the patient's body to the head of the bedstead, the desired result would be obtained. Continuous extension might also be advantageously employed in cases where attempts at immediate reduction had failed, with a reasonable hope that, under its influence aided by the patient's posture in bed, the luxated bone would be induced to slip into place again.

To sum up this branch of the treatment—the surgeon should seek to restore the displaced vertebra to its normal position by some one of, or, should the occasion require, by all the means of effecting reduction which have just been pointed out, that is, by arranging the patient's posture in bed, upon the back or upon the belly, according to the case; by making extension and counter-extension, under anæsthetics, with the help of skilled assistants; or by making continuous extension, which the surgeon can generally accomplish without skilled help.

Having fulfilled the first therapeutical indication, the surgeon must at once take care that the paralyzed bladder does not become over-filled with urine; for, should this occur, much harm would ensue. To this end, catheterization must be cautiously practised at least twice a day, with a soft instrument; and, at each time, the surgeon should cautiously compress the paralyzed bladder with his own hand, applied to the abdominal walls of the patient, in order to secure a complete evacuation of the viscus; for any urine that might be allowed to remain in it would, by undergoing decomposition, cause unnecessary mischief. Vesical and even renal inflammation may readily ensue in these cases. But this subject will be found to be more fully discussed under the head of Disorders of the Urinary Organs arising from Lesions of the Spinal Cord.

The surgeon must also take care that the patient is provided with such a bed as will least favor the occurrence of bed-sores; the best is a water-bed, the next best a good hair mattress. The surgeon must at every visit examine the private parts and buttocks of the patient, in order to see, for himself, that they are kept dry and clean, and are not inflamed, and that no gangrenous bleb nor eschar is forming. Motions of the bowels, when needed, should be procured by enemata rather than by purgatives. Immediately after a motion, the parts should be completely freed from feces by carefully wiping them, and then they should be cleansed by applying a spirit-lotion containing two per cent. of carbolic acid. This topic, however, will be more fully discussed under the head of Sacral Eschars and Acute Bed-Sores arising from Lesions of the Spinal Cord.

The occurrence of consecutive meningitis and myelitis must also be obviated as much as possible. I have already shown by a brief mention of seven

¹ Trans. Prov. Med. and Surg. Assoc., 1853.

examples, and by a reference to many others, that there exists, in every case of spinal dislocation or fracture, a more or less strong tendency for consecutive inflammation of the spinal membranes or spinal cord to ensue, and that in such cases the consecutive inflammation of the spinal membranes or spinal cord, by itself, not unfrequently causes death. Moreover, I shall presently show that consecutive inflammations of the spinal membranes and spinal cord, of this sort, always much increase the severity of the urinary symptoms and of the bed-sores which are met with in cases of vertebral dislocation and vertebral fracture, and that the prevention of these inflammations must be ranked among the most efficient means at our disposal for controlling these unhappy complications of spinal injury. Thus, one is enabled to perceive how important the fulfilment of the last-mentioned therapeutical indication really is.

Now, this indication is to be accomplished, that is, inflammation of the bruised and torn spinal meninges and spinal cord is to be obviated or controlled: (1) by reducing the vertebral displacement, as already directed; (2) by keeping the spinal column in a state of perfect rest, or as nearly immovable as possible, after the reduction has been effected; (3) should the patient's posture in bed permit, by drawing blood from the injured part by leeches or cups, and by applying dry cold, by means of an ice-bag, with compresses interposed, and, subsequently, by the employment of counter-irritants. But, whatever the patient's posture in bed, opium or morphia should be administered with sufficient freedom to allay pain and procure sleep, as already stated; and by keeping the patient somewhat under the influence of this drug until nature has repaired the breaches, much good can be done in the way of controlling any inflammatory action which may arise in the injured meninges; and, probably, in the spinal cord also. Potassium iodide, in doses of five grains every four hours, belladonna in full doses, and fluid extract of ergot, half a fluidrachm three times a day, will often prove to be very useful remedies for traumatic myelitis, as well as for traumatic spinal meningitis.

But, in attempting to reduce dislocations of the dorsal and lumbar vertebræ, is there not considerable danger that the spinal cord may be injured by the efforts of the surgeon himself? Many a person, doubtless, will be inclined to answer this question affirmatively, without much reason or reflection. Experience, however, has shown that this danger is more hypothetical than real. For example, reduction was effected in *fourteen* cases of displacement from injury of the dorsal or lumbar vertebræ, which are mentioned in Dr. Ashhurst's tables. In *eleven* instances the displacement occurred in the dorsal region; in *three* in the lumbar. *Seven* patients recovered, *two* were relieved, and *five* died. Of the cases in which the issue was successful I will not further speak; but the fatal ones I will briefly relate:—

(1) Higginson¹ is credited with the case of a man, aged 34, injured in the spine so that there was projection of the lumbar vertebræ one inch beyond the dorsal. Reduction was accomplished by making extension, under chloroform, with relief to the symptoms. In four weeks, however, he died; no account is given of the autopsy. (Ashhurst.) (2) Bryant² mentions the case of a laborer under Mr. Cock's care, aged 34, who fell from a scaffold across a wall. There were pain, paralysis, priapism, and deformity in the lower part of the spine. The last was removed by making extension and pressure. At the end of eight months death occurred. The *autopsy* showed dislocation forward of the eleventh dorsal vertebra and fracture of the twelfth; the cause of death is not stated. (Ashhurst.) (3) Holmes³ relates the case of a young man, aged 19, struck on the loins by falling timber. The last dorsal vertebra was dislocated. It was reduced by extension, and the reduction was attended by an audible sound. No relief

¹ British Medical Journal, 1862.

² Proc. Path. Soc. London, vol. viii.

³ Ibid., vol. x.

ensued. Death occurred twenty-three days after the accident. The *autopsy* showed dislocation with slight fracture of the twelfth dorsal vertebra, fracture of the first lumbar vertebra, and secondary deposits in both knee-joints. (Ashhurst.) (4) Luke¹ refers to the case of a man having fracture of the seventh dorsal vertebra, with displacement, which was reduced by extension, the reduction being accompanied by an audible sound. Death from erysipelas occurred seven days after the injury. The spinal cord was found to be softened and disorganized; there was purulent matter. (Ashhurst.) (5) Birkett² relates the case of a man, aged 31, who fell into the hold of a ship, striking his back, and dislocating the lower part of the spinal column. The fascia was torn off from several dorsal spines, and there was paralysis, etc. Extension under chloroform gave no relief; it was followed by great pain. At the end of four and a half months death ensued. The *autopsy* showed displacement of the eleventh from the twelfth dorsal vertebra, with fracture of the articular processes; spinal cord disorganized; supuration of the kidneys. (Ashhurst.)

In but one of these five cases can it be asserted with any plausibility that the efforts at reduction were themselves attended by any misadventure whatever. In the last case, the employment of extension did not relieve the symptoms, and was followed by severe pain. Still death did not occur until four and a half months afterward; and, whether the advent of the pain was merely a coincidence, or not, it is certain that the use of extension was not, *per se*, attended by any destructive lesion. In the other four examples, death was caused by erysipelas, by septicæmia, and, probably, by myelitis.

Moreover, three cases of vertebral fracture with considerable displacement are related by Professor König, of Göttingen, in the *Centralblatt für Chirurgie*, No. 7, 1880, in each of which the deformity was corrected by suspending the patient, without any bad effect; and, in No. 46 of the same journal, we find a paper by Dr. W. Wagner that tells of two similar cases. All five patients recovered.³

Thus, we perceive, that the experience recorded on this point is already rather voluminous, and that it decidedly favors the employment of judicious and intelligently directed efforts to reduce the displacements in cases of dorsal and lumbar dislocations and fractures, as well as in those of the cervical region.

FRACTURES OF THE VERTEBRÆ.

Men suffer from traumatic lesions of the vertebræ, from fractures as well as from dislocations of these bones, much more frequently than women, because the former, by their occupations, are much more exposed to the various accidents in life which cause these lesions, than the latter.

Fractures of the vertebræ may be, (1) *simple*, (2) *compound*, (3) *comminuted*, and (4) *complicated*. By a *pure* fracture is meant a simple fracture, which is not complicated with a dislocation. Compound fractures of the vertebræ are chiefly caused by the impact of gunshot missiles. *Gunshot fractures* of the vertebræ are of frequent occurrence. They constitute a special class of injuries, and will be separately considered. All forms of spinal fracture are frequently, but not necessarily, complicated with injury of the spinal cord, as well as with dislocation.

An inspection of the recorded cases of spinal injury involving the vertebræ and not caused by gunshot missiles, that is, of the recorded cases which occur in civil life, shows that the lesions consist of pure fractures in about one-fifth of the instances, of pure dislocations in another one-fifth, and of dislocations combined with fractures in the remaining three-fifths.

¹ *Lancet*, 1850.

² *British Medical Journal*, 1859.

³ *Medical News and Abstract*, 1881, p. 105.

Pure fractures of the vertebræ are of rather infrequent occurrence in the cervical region. Of 36 cases observed at Guy's Hospital, and mentioned by Mr. Bryant, in which the cervical vertebræ were injured, there was no example of pure fracture, while there were 11 examples of pure dislocation, and 25 examples of fracture combined with dislocation. Still, pure fractures of the cervical vertebræ are sometimes met with. I have already presented one instance, and shall mention several others. But it is in the dorsal and lumbar regions that most cases of pure fracture of the vertebræ are found, the very regions in which pure dislocations of the vertebræ least frequently occur. However, pure fractures fall much short of the majority in even these regions; for, of 18 cases in which the dorsal, and 2 cases in which the lumbar vertebræ were injured, that were observed at Guy's Hospital, and are mentioned by Mr. Bryant, nearly two-thirds appear to have been examples of fracture and dislocation combined.

In the 25 cases of cervical fracture combined with dislocation that were noted at Guy's Hospital, the lesion was below the third cervical vertebra in all but three examples. In one of these, it involved the second, third, and fourth cervical vertebræ; in another, the arch of the atlas and the spinous processes of the second and third vertebræ; and, in the third case, the bodies and laminae of the third, fourth, and fifth cervical vertebræ.

In the 18 dorsal cases, of all sorts, seven were in the upper and eleven in the lower half of the dorsal region. Thus, it seems clear that the lower parts of both the cervical and the dorsal regions are much more liable to fracture and dislocation than the upper parts.

The following case will serve to illustrate the most common form of fracture combined with dislocation, which is met with in the cervical region:—

On the morning of November 10, 1852, an unknown man, but poorly clad, was found lying dead on the cellar-bottom of an unfinished house at the corner of Franklin Street and Broadway, where it seems that he had fallen from the street, some time during the previous night. *Autopsy*, by the writer, at the Sixth Ward Station House, at 11 A. M., for the coroner.—Rigor mortis strong. Head and neck bent far forward. Spinous processes of the sixth and seventh cervical vertebræ movable. On exposing them by a free incision, the muscular and connective tissue around the sixth and seventh cervical vertebræ was found extensively infiltrated with blood. The spinous process of the seventh cervical (vertebra prominens) was broken short off. The laminae of the sixth cervical vertebra were fractured at a little distance from the spinous process of that vertebra, which accounts for the mobility of this spinous process also. The body of the sixth cervical vertebra was luxated forward from that of the seventh. The intervertebral substance, the anterior and posterior common ligaments, the capsular ligaments, and the ligamenta subflava were all torn through. The spinal cord was crushed by the displacement, and the theca vertebralis contained much blood. Externally, the theca was coated with blood.

The fractures of the laminae of the sixth, and of the spinous process of the seventh vertebra, were doubtless caused by striking the back part of the neck, at its root, upon the hard cellar-bottom; the laceration of the ligaments, and the displacement forward of the body of the sixth vertebra from that of the seventh, doubtless resulted from the extreme degree of flexion to which the spinal column was simultaneously subjected at the root of the neck.

Death quickly ensued, because of the cerebral concussion which attended the fall, and because of the shock which arose from the crushing of the spinal cord; but principally because of the extravasation of blood within the theca vertebralis, which speedily paralyzed the cord, by compressing it, as high as the roots of the phrenic nerves above the third vertebra, and thus completely arrested the respiratory movements.

This case is offered as an illustration, because, in most cases of fracture combined with dislocation that are observed in the cervical region, the laminae, or the spinous or transverse processes, are fractured, the ligamenta

subflava, the capsular ligaments, and the intervertebral disk are lacerated (more or less), and the body of the upper vertebra is thrown forward from that of the lower.

In the following example death suddenly resulted from falling upon the back in such a way as to crush three dorsal vertebræ, together with the spinal cord:—

Peter Riley, a laborer, fell from the walls of Trinity Chapel, then being built, on Saturday, November 27, 1852. He went down perpendicularly a distance of about fifty feet, and struck his back squarely across a beam. When picked up by his comrades immediately afterward, he spoke tenderly of his mother and sisters, and said "my back is broke." He died in about twenty minutes. At the *autopsy* I found the fourth, fifth, and sixth dorsal vertebræ much comminuted, that is, broken into many fragments. The muscles covering them were badly bruised and torn, and contained much extravasated blood. The skin, however, was not broken. An incision through the skin having been made, the soft parts investing these vertebræ were found so much disintegrated that, after picking out some fragments of broken bone, I thrust my fingers with ease directly through the spinal column into the right pleural cavity. The theca vertebralis and the spinal cord must also have been torn asunder.

The speediness with which death followed the injury in this case was due to shock, caused by the extent and severity of the spinal lesion itself, and to internal hemorrhage from the intercostal arteries that were torn, and, perhaps, from other sources. Professor Ashhurst¹ mentions a case taken from the Pennsylvania Hospital Records, which is somewhat similar to the last:—

A laborer fell from the sixth story, and thereby sustained a comminuted fracture of the lumbar vertebræ, fracture of the coccyx, and fractures of both legs. Death ensued in one day from exhaustion and internal (post-peritoneal) hemorrhage.

But comminuted fractures of the dorsal or lumbar vertebræ may be attended by rupture of the aorta, and death from internal hemorrhage may follow in the course of a few minutes. Several examples of this sort are on record:—

(1) Forster² mentions a case of Roper's, in which a man, aged 55, was knocked down and driven against by an omnibus. He was stunned, and in five minutes he died. Fracture of the fourth lumbar vertebra and laceration of the aorta were found. (2) Curling³ mentions the case of a rigger, aged 54, who fell from masthead to deck, and died in fifteen minutes. The *autopsy* showed fractures at the first, second, and third lumbar vertebræ, with rupture of the aorta. (3) Curling⁴ also reports the case of a wagoner, aged 46, supposed to have been run over by a wagon. He died in a few minutes. The *autopsy* showed fractures of the eighth, ninth, and tenth dorsal vertebræ; the aorta was ruptured. In such instances, however, the nature of the accident can often be correctly surmised from the seat of the fracture and the grating of the fragments, together with the sudden appearance of the signs of internal hemorrhage, such as a wax-like pallor of the countenance; lips bloodless, or dark-purple at their margins; cold sweats; weak, frequent, small, fluttering pulse; syncope, etc., ending quickly in death; but without any external flow of the extravasated blood.

Comminuted fractures of the dorsal or lumbar vertebræ are sometimes found to be compound, in consequence of the integuments and muscles being lacerated by the same exhibition of force which has caused the fractures themselves. Such fractures, probably, result most frequently from being crushed in railway collisions. "Brief mention is made in the reports of some instances of compound fracture of the spine from railway accidents."⁵ No details, however, of these instances are published; but, such cases must

¹ Op. cit., pp. 116, 117.

³ London Hosp. Reports, vol. i.

⁵ Circular No. 3, S. G. O., Aug. 17, 1871, p. 129.

² Proc. Path. Soc. London, vol. viii.

⁴ Ibid.

almost inevitably prove fatal, and all that the surgeon can do for them is to mitigate suffering by administering opiates and stimulants.

The following example will serve to illustrate one dangerous sequel which sometimes, perhaps often, presents itself in cases of simple vertebral fracture, namely, traumatic myelitis:—

Private John Hackey, Co. E, 6th Cavalry, aged 30, received, at Fort Waco, Texas, March 5, 1870, by falling from the second floor of a building occupied as barracks, a fracture of the fourth cervical vertebra. Complete paralysis, both sensory and motor, of the lower extremities, and of most of the trunk and upper extremities, immediately ensued. He was admitted to hospital without delay. But, on the morning of the 7th, he died of acute myelitis, about forty-eight hours after the accident. His intelligence remained unimpaired throughout. The treatment was sedative and stimulant.¹

The paraplegia which immediately ensued, in this case, appears to have been due to concussion of the spinal cord, for no mention is made of compression of the cord from displacement of bone nor from any other cause. The symptoms of concussion ran quickly into the symptoms of acute inflammation of the spinal cord, and death soon ensued.

In the following instructive case, there occurred simple fracture of the fifth cervical vertebra, without displacement of the fragments, and compression of the spinal cord from extravasation of blood at and around the seat of fracture:—

Private Emmet J., Co. A, 5th Infantry, aged 19, in diving from the bank of the Arkansas River, near Fort Lyon, Colorado, July 3, 1868, for the purpose of bathing, struck his head against the bottom, and immediately became powerless in the legs and arms. He would have drowned had no help been given. He was carried on a stretcher to the hospital, lying on his abdomen. Upon admission, at 1 P. M., the pulse, respiration, and temperature (although not counted) seemed normal; the pupils were unaffected; there was priapism. Power soon returned to his arms, although it was feeble. His extremities remained warm; and, when touched, sensation was found more acute, that is, less blunted, in the left than in the right leg. He complained of feeling dead below the neck. No irregularity or distortion of the spine was revealed by a careful examination; but, there was tenderness over the fifth cervical vertebra. A sinapism was applied to the nape of his neck; and, in an hour, he asked to be turned over, that is, on to the back. At 5 P. M. the pulse was 104; respiration 18; temperature 105°. Ice was applied to the upper part of the spine, a saline aperient was prescribed, and small pieces of ice given to be held in the mouth. At 9 P. M. the pulse was 100; respiration 24; temperature 102°; he was catheterized, and placed on a water-bed. On the morning of the 4th, the pulse, respiration, and temperature were all lessened. Cold applications to the spine were continued in the form of iced water, and the catheter was used twice during the day. At 5 P. M. the bowels were moved involuntarily. On the 5th, the temperature sank considerably below the normal (Fig. 861); sensation in the lower extremities was abolished; and the respiration was abdominal, that is, diaphragmatic. Dry rubbings were prescribed, with tonics, and nutritious food. On the 6th, sensation had partly returned to the left leg, and the breathing was better, there being more movement of the chest. By the 11th, the patient was able to pass his urine without a catheter, but sensibility did not return to the right leg. On the morning of the 13th, he had a chill, which recurred on the morning of the 14th, and again in the afternoon. After this, his countenance became dusky, and the temperature rose during the next

Fig. 860.

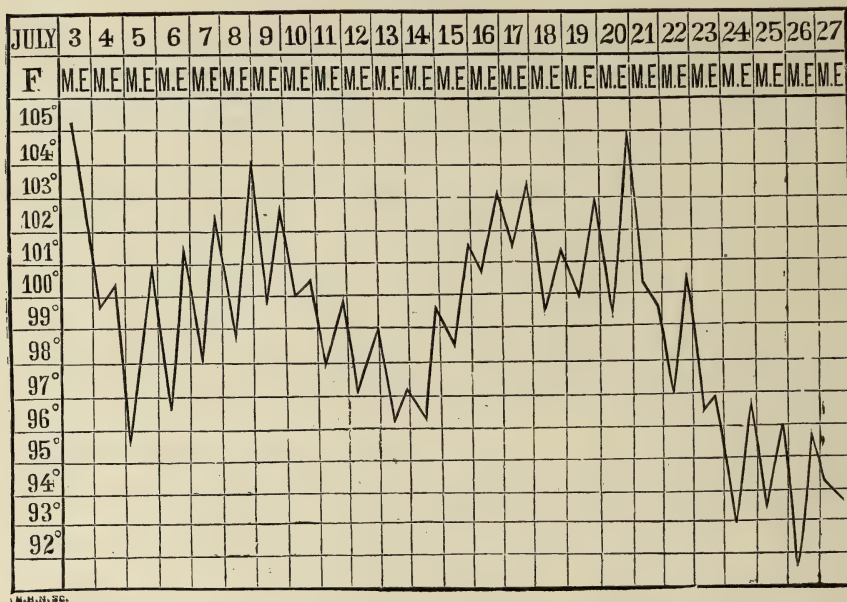


Showing fracture, without displacement, of the body of the fifth cervical vertebra. (Spec. 5724, Sect. I, A. M. M.)

¹ Circular No. 3, S. G. O., Aug. 17, 1871, p. 129.

three or four days. He had not perspired since the injury. On the morning of the 18th, the urine became turbid, the stomach was irritable, and he complained of his lungs feeling like stone. By the morning of the 20th, the pulse had become so feeble that it could not be counted, the bowels were loose, the urine was ammoniacal and

Fig. 861.



Thermograph of a fatal case of fracture, without displacement, of the fifth cervical vertebra.

thick with mucus, and vomiting occurred. Increased respiration and a very high temperature (105°) followed. On the 21st, catheterization had again to be employed, but the instrument was used with difficulty, owing to the formation of coagula in the bladder. He also suffered from bed-sores. By the 24th, his stomach became so irritable as to retain scarcely anything. On the 25th, there was complete anorexia. On the 26th, the temperature was 91.8° . He died at noon on the 28th. *Autopsy.*—Brain normal. The body of the fifth cervical vertebra was found fractured (Fig. 860). There was no displacement of the vertebra. It was ascertained that hemorrhage had compressed the spinal cord at and around the seat of fracture. In the dorsal region, the spinal canal showed no abnormality, excepting the spinal fluid which escaped. It was filled with transparent, floating globules, and resembled volatile-oil water. Lungs healthy, excepting the posterior portions, which were hypostatically congested; liver slightly enlarged. Splenic extremity of stomach congested. The kidneys were enlarged and engorged with blood; the pelvis of the left was filled with pus; but no other abscess could be found. The ureters were very dark in color, and one of them contained a clot at the entrance to the bladder. The walls of the bladder were dark-purple in color, inflamed, and thickened; its mucous membrane was absent in patches. The pathological specimens were sent to the Army Medical Museum.¹

Viewing the clinical history of this case in the light thrown upon it from the autopsy, the paralysis which instantly followed the injury appears to have been due to concussion of the spinal cord, and it may well be that injuries of a similar character, involving the upper part of the spinal column, are often attended by spinal concussion. However, the paralytic symptoms that were

¹ Circular No. 3, S. G. O., August 17, 1871, pp. 129-131.

due to concussion soon began to pass away, and on the following day were succeeded by the symptoms of compression of the spinal cord, caused by hemorrhage into the spinal canal, which increased in severity until sensibility as well as motor power was abolished in the lower part of the body, the respiration becoming diaphragmatic from paralysis of the other respiratory muscles, and the patient's temperature sinking to 95.8° on the morning of the second day. Then, the hemorrhage having ceased, the absorption of the extravasated blood was immediately commenced, and it was continued with so much activity that on the following day, July 6, sensation had partly returned to the left leg, and the respiration was better, for all of the chest-muscles again participated in the respiratory movements. By the 11th, he was so much improved that his micturition was entirely voluntary. But the sensibility did not return to his right leg, and this circumstance showed that the conducting filaments of the spinal cord itself were considerably injured, probably by contusion and ecchymosis of the cord-substance. On the 13th, or two days later, consecutive spinal meningitis and myelitis began with a chill, after which the patient's temperature rose considerably above the normal, and his countenance became dusky from vaso-motor paralysis. By the 20th, the inflammatory lesion of the spinal cord and membranes was attended by trophic lesions of the urinary bladder and kidneys, and of the soft parts over the sacrum and buttocks, which will hereafter be described under the head of Acute Bed-sores, and of Disorders of the Urinary Organs from Lesions of the Spinal Cord. The blood found in the bladder on the 21st had probably flowed into that organ through the ureters from the kidneys. The patient's stomach soon gave out entirely, and in a few days more he sank exhausted from vesical and renal inflammation, and from acute bed-sores.

The thermograph of this case (Fig. 861) shows at a glance three remarkable periods of depression in the temperature, the first of which corresponded to the compression of the spinal cord by extravasated blood (July 3 and 4); the second, to the invasion of the spinal cord and spinal meninges by consecutive inflammation (July 12, 13, 14); and the third, to the occurrence of exhaustion as the end drew near. After the first and second periods of depression, the temperature rose considerably.

By what symptoms externally perceptible was this fracture attended? By one only, to wit—by tenderness under pressure over the fifth cervical vertebra. In the absence, however, of distortion or deformity, or other evidence of luxation, the presence of fracture should be suspected in cases such as this. But the occurrence of spinal paralysis under such circumstances should not, *per se*, cause a fracture of the vertebræ to be surmised, since the paralysis might just as well result from concussion or contusion of the spinal cord, as it did in fact at the outset of this case. The spinal column was suddenly bent until it broke at the fifth cervical vertebra, but the fragments instantly sprang back into place again. At the same moment, the spinal cord was bent, stretched, and bruised; the spinal arteries were ruptured, hemorrhage therefrom ensued, and thus the symptoms of compression readily succeeded the symptoms of concussion of the spinal cord.

Besides these dangers, that is, contusion and compression of the spinal cord, together with spinal meningitis and myelitis, fractures of the upper cervical vertebræ are attended by others. Should the cord be crushed, or even pierced, above the roots of the phrenic nerves by a fragment of displaced bone, the respiratory movements would at once cease entirely, because the respiratory muscles would all be paralyzed, and death from asphyxia would immediately ensue. This accident not unfrequently happens, and the victims thereof but seldom, comparatively, receive the attention of surgeons. Abernethy, however, is credited with mentioning the case of a coal-heaver who fell from a

wagon while drunk. There was no apparent injury; still, he could not rise in bed; and, in turning his head to be shaved, he suddenly died. Fracture of a cervical vertebra was found; and the cord was penetrated by a splinter. The lesion must of course have been not lower than the third cervical vertebra.

Professor William Pepper¹ relates the case of a girl, aged 19, who broke her neck by falling from a pie-cherry tree, and was admitted to the Pennsylvania Hospital twenty-four hours afterward. All power to move the extremities and muscles of the trunk was gone. Sensation, too, was entirely lost from a little below the clavicle downward. There was retention of feces and urine; the bladder was much distended, no urine having been passed since the accident. The respiration was entirely diaphragmatic, and 32. The facies indicated great respiratory oppression. Pupils normal; intellect clear; voice feeble, and frequently interrupted; the tongue could be protruded at will, and moved in any direction. The cheeks were brightly flushed and very hot. The skin everywhere was much hotter than normal; pulse, small and frequent; temperature in axilla, 108.5°. "She abruptly asked to be raised in bed; her breathing became gulping and imperfect, and in less than two minutes she fell back dead." Pulsation was still perceptible at the wrist almost one minute, and the cardiac sounds were yet audible between three and four minutes, after the last respiration. *Autopsy.*—The tissues surrounding the cervical vertebræ were ecchymosed, and infiltrated with bloody serum, but no blood had escaped into the pharynx. There was a comminuted fracture of the atlas, the lateral masses being separated and the arches broken in two places. The fourth vertebra was luxated anteriorly from fracture of the articular processes.

The paraplegia which attended the accident was due to the forward luxation of the fourth cervical vertebra. The flushing of the face, and the great elevation of the body-heat were due to vaso-motor paralysis which resulted from injury of the sympathetic nerve. The sudden death was caused by puncturing the spinal cord with fragments of the broken atlas, and compressing it against the odontoid process of the axis. Not improbably, the girl's head slipped forward on the summit of the spinal column, when she was raised up in bed. The same accident occurred to this patient, on being raised up in bed, as befell one of Mr. Hilton's patients and nearly happened to another (whose cases have already been mentioned), where the ligaments belonging to the articulation of the head had been so extensively destroyed by disease, as to allow the head to slip forward and compress the spinal cord, with deadly effect, against the odontoid process of the axis. The sudden death of the patient whose case has just been related shows, that the same care is needed in cases of injury and in cases of disease of the first vertebra, alike, if the spinal cord be liable to sudden compression from the slipping or falling forward of the head, in consequence of the injury or the disease.

The following example teaches the same important lesson:—

Dr. H. F. Eberman,² reports the case of a man, aged about 70, who, while descending the steps from a hay-loft, slipped and fell, striking his occiput violently on the ground, and forcibly bending his head forward on to his chest. He lay insensible, for a considerable time. But, after recovering from the stunning, he arose, and placing both hands to his neck, walked to the bar-room of the hotel (half a square from the place of accident), where he remarked that he thought his neck was hurt, asked for a glass of whisky, and drank it. Then, he returned to the stable, and lay down on some hay; in about half an hour he expired. *Autopsy.*—The transverse process on the right side of the atlas was found to be broken off; the third cervical vertebra was fractured transversely through its body, the right arch was broken entirely through, and the articulating processes on both sides were fractured through the middle; the inter-spinous and posterior vertebral ligaments were ruptured; but the spinal cord remained intact.

¹ *Am. Journ. Med. Sciences*, April, 1867, pp. 438, 439.

² *Ibid.*, October, 1879, p. 590.

The sudden death of this man, too, was due no doubt to a compression of the spinal cord against the odontoid process of the axis, which was sudden caused by the elevating or thrusting forward of his head, and the subsidence of his neck, that would naturally occur when he turned over upon his back, as he lay flat on the hay, without a pillow to keep the nape of his neck raised up sufficiently to avoid such a calamity. This displacement of the fragments of the broken atlas, etc., could have been avoided by placing a small firm pillow under the patient's neck, when putting him to bed, and by confining his head and neck in a fixed position by means of heavy sand-bags so placed on either side thereof as to prevent all motion in the neck, as recommended by Mr. Hilton in analogous cases of cervical disease. Had such a proceeding been instituted, in this case, and continued until consolidation of the fractures had been effected, recovery no doubt would have ensued. The following example shows not only that this view is correct, but also that spontaneous recovery from similar fractures sometimes occurs:—

A man, aged 32, fell from a hay-wagon, striking his occiput on the ground, and was stunned.¹ He walked half a mile to visit a surgeon; in three days he resumed work; his neck was stiff, and there was tumefaction over the axis; after several months, dysphagia and tumefaction in the pharynx appeared. Nevertheless, he recovered; and, about one year and a half after the accident he died of pleurisy. The *autopsy* showed fractures of the atlas and odontoid process of the axis. (Ashhurst.)

As a symptom of the fractures of the atlas and third cervical vertebra which had occurred in Dr. Eberman's case, it may be mentioned that the man walked with a hand placed on each side of his neck, apparently in order to support it. Sir Astley Cooper² relates a case of simple fracture of the atlas, that was under the elder Cline's care, in which the same symptom was present:—

"A girl received a severe blow upon her neck; after which it was observed that, whenever she wanted to look at any object, either above or below her, she always supported her head with her hands, and then gradually and carefully elevated or depressed it, according as she wished, towards the object. After any sudden shock she used to run to a table, and placing her hands under her chin, rest them against the table, until the agitation caused by the concussion had subsided. Twelve months after the accident the child died; and on examination, a transverse fracture of the atlas was found, but no displacement. When the head was depressed or elevated, the dentiform process of the second vertebra became displaced, carrying with it a portion of the atlas, and occasioning pressure on the spinal marrow, which was also produced by any violent agitation."

Fractures of the odontoid process, as a rule, suddenly destroy life; the victims being literally pithed by that process. This accident often, but not always, proves instantly fatal.

For example, Melchiori³ mentions the case of a woman, aged 68, who was killed by falling from a ladder and striking her forehead on the ground. Death was instantaneous. *Dissection* showed fractures of the atlas and odontoid process of the axis; and the atlas was displaced backward. (Ashhurst.)

When, however, it happens that the fragments of the broken odontoid process are not displaced sufficiently to injure the spinal cord, the patient may survive until such a displacement is produced by some accident or other, as doubtless occurred in the following instance:—

Richet⁴ relates the case of a man, aged 22, who attempted suicide by a pistol-shot in the neck. He survived the injury for seventeen days, during which time he could

¹ Am. Journ. Med. Sciences, O. S., vol. xxiii.

³ Gaz. Medica Stati Sardi, 1850,

² Lectures, vol. ii. p. 8.

⁴ Thèse de Concours, 1851.

move only by supporting his head with his hands. Death suddenly occurred. *Dissection* showed fracture of the odontoid process. (Ashhurst.)

Professor Willard Parker, of New York, some years ago, had the case of a milkman, aged 40, who was injured by being thrown from a wagon about fifteen feet, and striking his head and face on the ground. There was pain in the neck and a protuberance on the left side thereof. He could not turn his head, but supported it with his hands. He got so well that he resumed his milk business, and survived the injury for five months. He died suddenly, after a hard day's work, on the fragments becoming displaced by an accident, his head dropping forward upon his chest, at the table, to such a degree as to compress the spinal cord. *Dissection* showed fracture of the odontoid process; and the lower end turned back to the spinal cord.

This patient would have recovered had he but kept his head and neck at perfect rest until consolidation of the fracture had ensued. In the following example recovery did take place, and some time afterward the man died of a non-surgical disorder:—

Mr. B. Phillips¹ had under his care a laborer, aged 32, injured by falling head foremost from a hay-rick. In a little while he was able to arise. In two days he went to work again. A month afterwards, he walked two miles to consult his surgeon. His neck was stiff, there was a protuberance at the back of the pharynx, with some difficulty in swallowing, but no paralysis. One year after the accident he died from dropsy. The *autopsy* showed fractures of the atlas and odontoid process, with displacement of some pieces forward against the pharynx; the occipital bone had settled down on the axis, and formed a new joint; the spinal cord was unhurt. The spinal foramen in the first and second vertebræ is quite large; and, therefore, these bones may be extensively damaged without seriously injuring the spinal cord.

Mr. R. Debenham² also mentions a case in which the odontoid process was fractured, and recovery followed. The subject was a shoemaker, and the lesion was verified by dissection two years after the accident. Cases in which the odontoid process was spontaneously fractured, that is, fractured in consequence of disease, have been reported by Hyrtl, by Else, and by Flint; and, in each instance, death occurred instantaneously.³

Professor Stephen Smith, in an article on "Fracture of the Odontoid Process,"⁴ has collected twenty-two cases. Six occurred spontaneously, in consequence of disease, and all ended fatally except one, in which a portion of the bone was discharged through the throat; four were gunshot cases, all fatal; seven were caused by external violence, all likewise fatal; five were cases in which a portion of the bone had been discharged, with four recoveries and one death; aggregating but five recoveries and seventeen deaths. Dr. Smith has found, by experiment, that, although the odontoid process is not fractured by being driven against the transverse ligament on the anterior arch of the atlas, the odontoid ligaments combined are stronger than the odontoid process, and "that the efficient agents in this fracture are the odontoid ligaments." The odontoid process has been fractured from violence directly applied; and from external violence indirectly applied, *e.g.*, to the forehead, to the side of the head, and to the back part of the neck. The symptoms of this accident are pain and stiffness in the neck, swelling in the region of the first and second vertebræ, and a protuberance in the pharynx at the same region; but, probably, the chief symptom is that the patient carries the head supported on the two hands. This symptom, however, has been observed in cases where the occipito-atloid articulation, that is, the *articulatio capitis*, has been disrupted,

¹ Medico-Chirurgical Transactions, vol. xx. p. 78.

² London Hosp. Reports, vol. iv. p. 210.

³ P. Bevan (Dublin Med. Press, February, 1863) reports a case in which there was fracture of the odontoid process, perfect ankylosis of its apex with the occipital bone, and partial luxation forward of the atlas. (New Syd. Soc. Year-book, 1864, p. 280.)

⁴ American Journal of the Medical Sciences, October, 1871, pp. 338-58.

as well as in cases where the bones forming the atlo-axoid articulations have been broken; and, generally, it denotes that either the atlas, or the axis, or both of these bones are fractured.¹

“*Latent Fracture of the Spine*,” as Mr. Simon has denominated an important lesion of the spinal column which occasionally presents itself to surgeons, must also be considered in connection with those fractures of the vertebræ which are attended by but little or no displacement of the fragments. In the examples of so-called latent fracture of the vertebræ, the spinal cord is not at all affected by concussion, nor by contusion, nor is it compressed by displaced bone, nor by extravasated blood. The breach, in these cases, usually consists of a linear fracture through the body of a cervical or a dorsal vertebra. On the withdrawal of the force which fissures the bone, the fragments at once spring back into place again. The patient complains only of pain, soreness, and stiffness in the injured part of the spine, for some days; and, perhaps, having returned to work, continues at the same until the symptoms of suppurative inflammation present themselves at the seat of the fracture, and until an abscess forms in the spinal canal between the theca vertebralis and the bone, as well as external to the bone, in the same locality. These cases are strictly analogous to those of circumscribed abscess occurring between the dura mater and the bone, in consequence of a linear fracture of the skull, which have often been observed in latent injuries of the head. As subcranial abscesses not unfrequently cause death, *per se*, by compressing the brain, even so these cases may terminate in death by compression of the spinal cord, without the occurrence of that diffused traumatic spinal meningitis or myelitis which often supervenes, as we have already shown, in cases of vertebral fracture or dislocation. Mr. Simon² relates an instructive example of the spinal lesion in question:—

A girl, aged 18, injured her neck by falling, in the dark, about twelve feet down an embankment. At first she was stunned. Afterward she walked home, a distance of about three miles. She resumed work, and remained thereat for eleven days. She entered St. Thomas's Hospital on the fifteenth day after the accident, on account of severe pain in her neck, with fever, etc. No displacement nor irregularity of the spine could be detected. There was no anæsthesia nor paralysis. Her complaints of pain and tenderness were vague. She chiefly spoke of suffering between the shoulders; turning over into a prone position in bed was accomplished slowly, stiffly, and with cries. Early on the sixteenth day, she complained of numbness and twitching in her limbs, particularly in the lower; in the evening, voluntary motion was lost completely in the legs, and nearly in the arms; sensibility was likewise very much impaired in both. Delirium, “jumping of the legs,” and tympanitic distension of the abdomen, as well as high fever now appeared. On the eighteenth day she died. *Autopsy*, 30 hours after death—“A horizontal line of fracture was found traversing the body of the seventh cervical vertebra, just above its inferior surface. Beyond a very little gaping in front, which would allow the edge of a scalpel to be insinuated flatly between the fragments, there was not the slightest displacement; and the posterior common ligament was untorn. The spinal canal contained between the osseous walls and the dura mater [theca vertebralis] a large quantity of pus, which, from two inches below the foramen magnum, descended the whole length of the cord. At the several intervertebral holes it had crept somewhat along the issuing nerve-sheaths, and, between the first and second dorsal vertebræ had

¹ But fracture of the axis unattended by any notable displacement may prove quickly fatal, by causing hemorrhage into the spinal canal, and compression of the spinal cord therefrom, as happened in the following instance: Arnott (Lancet, 1851) reported the case of a man, aged 74, injured in the neck by falling down stairs. There was paralysis of the upper extremities, but not of the lower. In one hour death ensued. *Dissection* showed fracture of the spinous process of the axis; the fragment was wedged in between the axis and the third vertebra. There was effusion of blood in the vertebral canal. (Ashhurst.)

² Transactions of the Pathological Society of London, vol. vi. p. 42.

actually emerged, following the subdivision of the first dorsal nerve, so as to spread among the exterior parts. These burrowings of matter were cut into before the [spinal] canal was opened. . . . The outer surface of the [spinal] dura mater was roughened by inflammatory deposits; but none were found within it; nor was there any softening, or microscopical change in the spinal cord. No other disease was discovered."

The fracture of the seventh cervical vertebra was called latent, or concealed, in this case, because it was not attended by deformity, nor by any other symptom of special import, for a considerable number of days. Meanwhile, the connective tissue lying between the theca vertebralis and the bone became inflamed, commencing at the fracture, and purulent matter in great quantity was formed and collected in this tissue, whereby the spinal cord was compressed through the medium of the theca; but life was not destroyed until the intra-vertebral abscess had burrowed upward far enough to compress and paralyze the respiratory centres, thus arresting completely the respiratory movements and causing death by asphyxia. The abscess external to the spinal column was not large in this case. In other instances, however, the exterior abscess is found to be quite large, and to burrow extensively in the soft parts around the spinal column, as was noted in the following instance:—

Sir B. C. Brodie¹ mentions the case of a man, aged 45, who fell from a scaffold and injured his back. There was paralysis, followed by convulsions. Death ensued nine weeks after the accident. *Dissection* showed fracture of the fourth dorsal vertebra; the spinal cord was compressed and softened; an abscess arising from the seat of the fracture extended into the posterior mediastinum. (Ashhurst.)

It is not the fracture itself which destroys life in these cases of latent vertebral injury, but the consecutive inflammation and abscess; and, if these untoward consequences of such injuries be averted, complete recovery will ensue. The symptoms directly after the injury, in cases of latent fracture of the spinal column, closely resemble those which are met with in sprains or wrenches of the vertebral joints, caused by blows on the back, falling, etc.

Mr. Bryant² mentions, in point, the case of a woman admitted into Guy's Hospital, under Mr. Cock's care, for some injury of the back caused by falling out of a window. "Beyond the contusion, no injury could be made out." She died, however, of cerebral disease sixteen days after the accident. *Dissection* showed that the last dorsal and three upper lumbar vertebræ were fractured through their bodies, but not displaced; one or two spinous processes were also fractured. The spinal marrow was uninjured. The fact of there being no displacement of the broken bones, and no injury of the spinal cord, had prevented the making of a correct diagnosis in this case.

But examples, such as this, of vertebral fracture wherein the diagnosis is not made until the post-mortem examination, are not uncommon. It is, therefore, rather important for the surgeon to bear the latter fact in mind while treating cases of supposed sprains, wrenches, and twists of the vertebral joints, and to enforce, in all doubtful cases, that absolute quietude of body—that freedom from all movement, particularly in the injured portion of the spinal column—which is necessary in order to secure consolidation of the fracture without accident, should this lesion perchance be present.

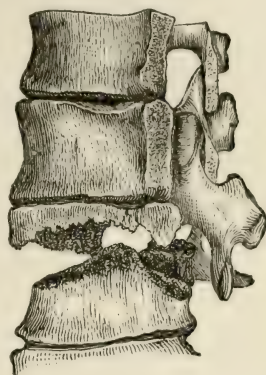
In cases of vertebral fracture occurring in the dorsal region, it should be stated that displacement of the fragments is measurably prevented by the ribs acting as splints placed on each side of the spinal column. In the lumbar region, likewise, the great lumbar muscles may act powerfully in the way of preventing and removing displacement, in cases of vertebral fracture, unattended by dislocation, as the following example will show:—

¹ Medico-Chirurgical Transactions, vol. xx.

² Op. cit., p. 202.

Corporal John B., Company C, 10th New York Volunteers, March 11, 1865, at Hatcher's Run, Va., was struck across the dorsal and lumbar regions by the falling limb of a tree which had been severed by a shell. He was knocked senseless, and remained so an hour or more, until he was awakened by the jolting of the ambulance that carried him to regimental headquarters. On regaining consciousness, he was unable to move the lower portion of his body, and complained of pain in the same parts. He was cupped, and had mustard applied to the calves of his legs and to the spinal region. The symptoms still continuing, he was blistered, and the blisters were dressed with lint. On the 19th, he entered Finley Hospital, at Washington; he was then semi-comatose; there was complete motor paraplegia, but sensation was perfect. There was some febrile action, pulse full and bounding, and very severe diarrhœa; feces and urine passed involuntarily; both legs were very cold, the left slightly more than the right; skin moist, the blistered parts on each leg were suppurating slightly. The parts in the region of the sacrum were gangrenous. Opiates were given at night, and chlorides used to cleanse the gangrenous sore over the sacrum. Under the administration of astringents, the diarrhœa ceased by the 25th. The patient, however, continued to sink, and died on the 29th, apparently from exhaustion (septicæmia?).

Fig. 862.



Pure or simple transverse fracture of the first lumbar vertebra, caused by the limb of a tree falling upon the loins and back of a soldier. (Spec. 149, Sect. I, A. M. M.)

Autopsy.—The first lumbar vertebra was found fractured entirely through its body at the upper third (Fig. 862), with each pedicle broken, and the left transverse and spinous processes impinging against the spinal cord, which was lacerated at the lumbo-dorsal junction. The spinal meninges were torn entirely across, excepting a few fibres anteriorly and posteriorly, and were congested above and below the rent. Blood-clots were found diffused in the tissues around the fracture. The spinal cord was lacerated in a singular manner, and a wood-cut representing it (Fig. 879) is given on p. 397.

In this example, the fracture of the vertebral column, although it extended completely through the same (Fig. 862), and constituted a false point of motion, appears to have not been recognized until the examination after death. The principal cause of this failure to make a diagnosis, appears to have been the fact that there was no appreciable displacement. Thus, the spinal symptoms were supposed to arise from concussion of the spinal cord; and the illusion itself was furthered by the fact that the paralysis was motor, but not sensory. The occurrence of displacement seems to have been prevented by the action of the lumbar muscles.

Three cases of pure fracture of the dorsal and lumbar vertebræ are mentioned by Mr. Bryant.¹ In one of them the fourth and fifth dorsal vertebræ were comminuted; in another, the eighth, ninth, and tenth were fractured through their bodies and laminae; and, in the third, the twelfth dorsal and three upper lumbar vertebræ were extensively broken. In one of them certainly, and in all of them possibly, no displacement was to be detected by an external examination. The fragments appear to have been held in position by the ribs, and by the great muscles which are in relation with the spinal column in the dorsal and lumbar regions.

But in other instances of pure dorsal and lumbar fractures, the displacement of the fragments is such that it can readily be perceived on making an external examination. For example:—

Dr. H. J. Bigelow² gives the case of a young woman, aged 19, who jumped from a

¹ New Syd. Soc. Retrospect, 1867–8, p. 276.

² Am. Journ. of the Med. Sciences, N. S. vol. xxi.

second-story window, and alighted upon her buttocks, thereby fracturing her spine. There was a projection of the lower dorsal vertebræ and paralysis. The latter diminished after two weeks, and partial recovery ensued. In eight and a half months, however, she died of phthisis. The *autopsy* showed fractures of the last dorsal and of the first and second lumbar vertebræ; the spinal cord was compressed; provisional callus had formed. (Ashhurst.) It is worthy of special note, in this case, that the patient partially recovered, and that the disease which caused her death was not connected with the injury.

Fractures combined with dislocation often occur in the dorsal region. They generally take place between the tenth, eleventh, and twelfth dorsal vertebræ. In such cases the body of the superior vertebra is usually dislocated forward, and the body of the inferior vertebra fractured; the arch of the inferior vertebra is, as a rule, also broken. (Bryant.) A specimen showing dislocation of the first, and fracture of the second lumbar vertebra, taken from a patient who had survived the accident for three and a half years, is described and figured by Mr. W. Wagstaffe.¹

Fractures of the spinous processes, unattended by dislocation or by fracture of any other portions of the vertebræ, that is, pure fractures of the spinous processes, not unfrequently occur. They are met with in the cervical, the dorsal, and the lumbar regions alike, and are always caused by the direct application of force. They may be simple or compound; and compound fractures of the spinous processes are often caused by the impact of small-arm missiles. Generally, pure fractures of the spinous processes are not attended by spinal paralysis. When, however, spinal symptoms are present, in such cases, they usually arise from concussion of the spinal cord, though, in some rare instances, they have been found to be due to compression of the spinal cord by extravasated blood. Generally, pure fractures of the spinous processes, whether simple or compound, terminate in recovery without giving much trouble. I have seen a considerable number of examples belonging to the latter category,² and cannot now call to mind any case among them that did not end favorably. In one instance, there was severe concussion of the spinal cord also, and a fragment of the broken spinous process exfoliated. The experience of other observers supports the view that pure fractures of the spinous processes generally terminate in recovery without much difficulty.

Sir A. Cooper³ mentions the case of a boy injured by thrusting his head between the spokes of a wheel. There was distortion of the spine, and fracture of three or four spinous processes, but no paralysis. "He quickly recovered without any particular attention." The deformity, however, remained. (Ashhurst.)

"When I was a dresser," says Mr. Bryant, "I saw a case of fracture of the spinous processes of three cervical vertebræ associated with a temporary paralysis; and, in this instance, complete recovery ensued; I have since successfully treated a case of fracture and displacement of the spinous process of the fourth cervical vertebra, without paralysis. . . . I have seen also a case of fracture of the spinous processes of the last dorsal and first lumbar vertebræ with lateral displacement, the injury having been treated for some months previously as a simple contusion of the back. In this case, no paralysis existed or other spinal symptoms."⁴

On the other hand, when perchance the broken-off portion of the spinous process gets impacted between the laminae, and presses upon the spinal cord, death sometimes quickly ensues.

¹ Trans. of the Patholog. Soc. of London, vol. xxi. p. 327.

² Am. Journal of the Med. Sciences, October, 1864, pp. 315, 327.

³ Disloc. and Fract. of Joints.

⁴ Practice of Surgery, p. 201.

For example, Mr. Erichsen mentions the case of a woman admitted into University College Hospital, with an injury of the neck, the nature of which could not be accurately ascertained. She was in no way paralyzed, but kept her head in an immovably fixed position. A few days after admission, whilst sitting up in bed, being startled by a noise, she suddenly turned her head, and fell back dead. *Dissection* showed that the spinous process of the fifth cervical vertebra was broken off short at its root, and was impacted in such a way between the arches of this and the arches of the fourth vertebra as to compress the cord.¹ The impaction of the fragment and the compression of the spinal cord probably occurred at the instant of the involuntary movement of the head.

I have already presented, in a foot-note, a somewhat similar case of Mr. Arnott's, in which a man, aged 74, fell down stairs and injured his neck. There was paralysis of the upper extremities, but not of the lower. In one hour death ensued. *Dissection* showed that the spinous process of the axis was fractured, and that the fragment was wedged in between the axis and the third vertebra; there was also effusion of blood in the vertebral canal, which probably caused death by compressing the cord. Notwithstanding these exceptions, the rule concerning the result in cases of pure fracture of the spinous processes, is as already stated, namely, that they generally end in recovery. Professor Agnew mentions the case of a young man, under his own care, in which the detached portion of a spinous process remained for several months movable, finally became necrosed, and was discharged through a sinus.²

Symptoms and Diagnosis of Fractures of the Vertebrae.—When the fracture is *compound*, as it is in cases where small-arm missiles break the spinal column, the diagnosis can generally be settled with certainty by exploring the wound with the finger. In cases where the aperture in the integuments is not large enough to admit a finger, *e. g.*, wounds made by buckshot and small pistol-balls, the exploration may be made with the porcelain-tipped probe of Nélaton, or with the ordinary bullet-probe, and thus, likewise, the lesion of bone, if it be present, can generally be made out. In cases where the orifice of the wound is too far away from the spinal column to admit of examining it with a finger in the wound, the exploration must be made with a probe, in order to determine whether there is a fracture of the vertebræ or not; and, in case there is, what part or parts of the vertebræ are broken.

Simple fractures of the *spinous processes* are attended by the following phenomena: Ecchymosis of the integuments covering the seat of fracture, pain and tenderness under pressure, also at the seat of fracture, with displacement and abnormal mobility of the broken spinous processes. If these be grasped by the thumb and fingers, they can be swayed from side to side, and the grating of the broken surfaces against each other will be felt by both patient and surgeon, as these movements of the broken-off portions of the spinous processes are made. But abnormal mobility may be imparted to the spinous processes from fractures of the corresponding pairs of laminae to which they are attached, as was noted in at least one of the cases above mentioned. Mobility of the spinous processes arising from this cause, however, is not very liable to be mistaken for mobility arising from fracture of the processes themselves, inasmuch as there are essential differences between the false points of motion in the two cases; and no one having once had his attention called to the subject, would be likely to mistake the abnormal mobility of the vertebral spines which may result from fractures of the laminae they are attached to, for that which results from fractures of the spinous processes themselves. Again, when the patient bends the injured part of the spine strongly forward, and thus greatly increases the tension of the integuments over it, as well as the disposition of the spinous processes

¹ Science and Art of Surgery, p. 291, Am. ed. 1854.

² Op. cit., vol. i. p. 825

to separate from each other, the deformity is correspondingly increased and the sufferings are correspondingly aggravated, in cases where the spinous processes are fractured.

Simple fracture of the *laminae*, with displacement forward of the fragment embraced between the two lines of fracture, may be produced by a blow upon the spinous process which springs from them. This lesion is denoted by ecchymosis of the integuments, by local pain, stiffness, and tenderness under pressure, by depression of the broken *laminae* themselves as well as of the spinous process attached to them, and by feeling the broken *laminae* move when the corresponding spinous process is moved from side to side. In such cases, the spinal cord is liable to be seriously injured by the depressed fragments of the broken *laminae*; and, therefore, the symptoms of spinal paralysis are usually present whenever the *laminae* are fractured. In such cases, too, the patients themselves will feel the grating of the fragments, and will be likely to inform the surgeon to that effect if inquiry be made concerning it. Moreover, the surgeon should be very careful in regard to making pressure upon the spinous processes and bending them from side to side, in such cases, lest he may himself crush the spinal cord, or do some other irreparable injury to it. Oftentimes, the spinal cord is severely injured by the accident itself, in such cases, as the following examples will show:—

Dr. T. B. Ladd¹ reports the case of a man, aged 30, whose neck was injured by being thrown in wrestling, etc. There were paralysis, pain, fever, and dyspnoea before death, which occurred thirty-six and one-half days after the injury. *Dissection* revealed a fracture of the arch of the fifth cervical vertebra; the spinal cord itself was compressed and disorganized. (Ashhurst.) The spinal cord appears to have been severely compressed by the fractured *laminae*, and disorganized by ascending myelitis. No doubt death was preceded by diaphragmatic breathing and paralysis of the respiratory muscles, in consequence of the respiratory centres being invaded by the myelitis. Likewise, Professor Hamilton mentions in his excellent Treatise on Fractures and Dislocations, the case of a man, aged 40, injured by a balustrade striking on his neck and head. There was paralysis, pain, etc.; and, in thirty-six hours, death ensued. *Dissection* showed fracture of the arch of the sixth cervical vertebra; the cord was compressed. It is not improbable that, in this case, death was directly caused by acute ascending myelitis.

Simple fractures of the *bodies*, *pedicles*, *transverse*, and *articular processes* of the vertebrae are more deeply covered up by muscles, fasciae, and integuments, than the fractures just discussed; and, therefore, are diagnosticated with much greater difficulty. Generally, they cannot be separated from each other with certainty during life. They are attended by the following symptoms: Impairment of function, pain, and tenderness under pressure at the seat of fracture, subtegumentary extravasation of blood, more or less displacement of the fragments (sometimes it is very slight), and crepitus. The last-mentioned is the most important of all the signs; and, when distinctly felt, it removes all doubt as to the diagnosis of the fracture. But, while it is not allowable for surgeons to flex and extend, or to rotate and compress, the spinal columns of their patients merely for the purpose of ascertaining, by a manual examination, whether there be crepitus, nevertheless, this point can generally be settled by asking the patients themselves whether they have felt the “grating” of broken bones in the injured part, and by applying a flexible stethoscope, or the hand, over the injured place, while the patient is being turned over in bed in order for the nurse to cleanse the private parts, or while he is being moved for any other necessary cause. Thus, the surgeon by watching for an opportunity to make a manual examination, can generally settle the

¹ Boston Med. and Surgical Journal, 1852.

question of crepitus, without violating any canon of his art. The following examples will illustrate in a useful manner the symptomatology of these vertebral fractures:—

Dr. F. H. Hamilton, Jr.,¹ reports the case of a soldier, who fell twenty feet, striking his neck. There were crepitus over the second and sixth cervical vertebræ, with slight pain and paralysis, and a compound fracture of the thigh, unperceived by the patient. Death ensued forty hours after the accident. *Dissection* showed fractures of the spinous processes of the second and the third, and a longitudinal fracture of the body of the sixth cervical vertebra; the spinal cord was compressed. (Ashhurst.) Dr. Hiram A. Prout² mentions the case of a man, aged 30, who was injured in the neck while wrestling. There were paralysis, pain, and crepitus over the fifth cervical vertebra; and, forty-eight hours after the casualty, death occurred. *Dissection* revealed a fracture of the fifth cervical vertebra, the spinal cord compressed, and an effusion of blood in the spinal canal. (Ashhurst.) Professor Hamilton, in his excellent Treatise on Fractures and Dislocations, refers to the case of a man, injured in the neck by being thrown backward from a wagon, and striking his head. There was paralysis, with crepitus in the upper part of the cervical region; and his breathing nearly ceased when he was turned over upon his face. Forty-eight hours after the accident, death ensued. There was no autopsy. Paul Belcher³ relates the case of a sawyer, aged 37, who fell from a cart while drunk. He was stunned and had a scalp-wound. There were pain, paralysis, and priapism. On the next day, crepitus over the first and second dorsal vertebræ was noted. He died fifteen days after the injury. *Dissection* showed fractures of the first and second dorsal vertebræ; a small clot in the spinal canal; the theca vertebralis torn; and the spinal cord diffuent. (Ashhurst.) In this case, intra-spinal hemorrhage arose from the injury, as in Prout's case just mentioned. It seems that a myelitis also arose from the injury, which disorganized the spinal cord and destroyed life.

Simple fractures of the bodies of the vertebræ have been met with most often in the parts of the spinal column which allow the greatest range of motion, to wit, between the third and seventh cervical vertebræ, between the eleventh dorsal and second lumbar, and between the fourth lumbar and the sacrum.

The *direction* of these fractures of the bodies of the vertebræ may be transverse, oblique, or vertical. The oblique and vertical lines of fracture may pass through the bodies of two or three vertebræ successively. Sometimes the lines run in several different directions in the same vertebra, as, for instance, when the fracture is comminuted. The lines of fracture may simultaneously extend through the laminæ or pedicles, as well as through the bodies of the vertebræ. When the direction is oblique, Malgaigne thinks that the fracture always extends from above downward and from behind forward, and constitutes a sort of inclined plane, down which the upper fragment slides, unless it is restrained by the vertebral ligaments. Malgaigne's views on this point are supported by the observations of other surgeons. This is the chief way in which displacement results from fractures through the bodies of the vertebræ.

It is scarcely necessary to say that the displacement arising from *fractures* is quite distinct from that which arises from *luxations* of the bodies of the vertebræ. It is likewise scarcely necessary to say that the displacement arising from fractures may be attended with an overlapping of the lower fragment, caused by the sliding downward and forward of the upper fragment, and that an appreciable shortening of the spinal column may be produced in this manner. When *shortening* of any part of the spinal column is caused by vertebral injury, it affords undoubted evidence, not only that there is fracture, but also that the fracture involves the body of one, or more than one, vertebra at that part. The following example will usefully illustrate this point:—

¹ American Med. Times, N. S., vol. viii.

² American Journ. Med. Sciences, 1837.

³ British Med. Journal, 1862.

Dr. T. G. Morton¹ reports the case of a young man, aged 19, injured by falling into the hold of a vessel, and striking his head and neck. The neck was shortened, and the head thrown forward. There were pain, paralysis, and priapism, with "symptoms of concussion." In ten days death ensued. *Dissection* showed fractures of the fourth, fifth, and sixth cervical vertebræ; partial dislocation of the fifth; the spinal cord was compressed, and there were blood-clots in the vertebral canal. (Ashhurst.) To the symptoms of fracture of the bodies of the vertebræ already mentioned, *shortening* of the spinal column, when it is caused by vertebral injury, must, therefore be added.

By the displacement of the fragments, which results from certain fractures of the bodies of the vertebræ, the spinal cord may be bruised, compressed, or even severed; and, in this way, *spinal paralysis, priapism, retention of urine and feces, bed-sores*, etc., are not unfrequently produced. But spinal paralysis, appearing coincidently with the accident which causes the fracture, is quite as likely to arise from concussion of the spinal cord as from compression thereof; for fractures of the bodies of the vertebræ are often attended by concussion of the spinal cord—much oftener, I fancy, than luxations. When spinal paralysis begins a few hours after the accident, in the lower extremities, and creeps gradually upward, it is generally due to extravasation of blood within the theca vertebralis. Many examples have already been presented.² When spinal paralysis begins at a later period, it is often caused by spinal meningitis or myelitis.³ But much displacement of the fragments, *without* the occurrence of spinal paralysis, has often been observed in cases where the lower dorsal and the lumbar vertebræ were fractured. For example, Mr. Shaw⁴ reports four cases in which the lower dorsal and the upper lumbar vertebræ were fractured, and the fragments much displaced, without causing any spinal paralysis. These patients all recovered more or less completely. It will be remembered that the spinal cord, having progressively diminished in size in the dorsal region, terminates in adults in a rounded point at the first or second lumbar vertebra, after sending off the cauda equina; in children, at birth, it extends to the middle of the third lumbar vertebra, and, in the embryo, is prolonged as far as the coccyx. Dr. Bennett⁵ relates a case of fracture of the third lumbar vertebra from direct violence, without the spinal canal suffering from encroachment.

Local *pain*, as already stated, is usually present in cases where the bodies and pedicles, etc., of the vertebræ are broken. But when the spinal nerves also are injured by fracture-splinters, especially during their passage through the intervertebral foramina, severe pain is excited in their terminal branches, which appears to the unfortunate patient to be fixed in the parts supplied by the injured nerves. For instance, when the sixth, seventh, or eighth dorsal nerve is thus irritated at the intervertebral foramen, pain and perhaps cramps, corresponding to the irritation, will be felt in the part of the abdominal walls where the terminal branches of the injured nerve are distributed. The presence of such a pain not unfrequently furnishes important aid in diagnosing a vertebral fracture.

The symptoms and diagnosis of the so-called *latent fractures* of the bodies of the vertebræ yet remain to be considered. These cases are not attended by appreciable displacement of the fragments during life, nor by crepitus, nor by shortening of the spinal column, nor, at the outset, by spinal paralysis. They bear a close resemblance to instances of sprains or wrenches of the vertebral joints. Like sprains, they are caused by blows on the back, or by falls, etc.

¹ Proceedings Pathol. Soc. Philadelphia, vol. i.

² For a further discussion of these important topics, see *Injuries of the Spinal Cord*, *infra*.

³ See *Traumatic Meningitis and Traumatic Myelitis*, *infra*.

⁴ Med. Gazette, vol. xvii., and Trans. Pathol. Soc. London, vol. iii.

⁵ Dublin Quart. Journal, February, 1869.

Like sprains or wrenches, they are attended by local pain and tenderness under pressure, by tumefaction, by ecchymosis, and by impaired function of the injured part. There are, however, some important differences: 1. In the cases of spinal fracture the tenderness is usually restricted to one or two vertebræ, whilst in the cases of sprain it is diffused over the joints of several contiguous vertebræ which have suffered almost alike. 2. The functions of the spinal column, as an instrument for mechanically supporting the body, are usually affected to a much greater extent by latent fractures than by sprains. In an instance of the former, which came under my own observation, there was utter inability on the part of the patient to sit upright in a chair or bed without assistance, although there was no paralysis. Had the case been merely a sprain, and not a fracture of the spinal column, the patient would have been able to sit upright, unaided, when placed in a chair or raised up in bed. In a case of Abernethy's, mentioned above, the patient could not raise himself in bed, and there was no reason apparent for this inability until the fracture was revealed by the autopsy. By attending to these two points, then, latent fractures can sometimes be distinguished from sprains or wrenches of the vertebral column.

Prognosis.—In cases of vertebral fracture the prognosis is never favorable, unless the lesion chance to be restricted to the spinous processes, as already stated. But fractures occurring in the cervical region are more dangerous than those in the dorsal region, and these in turn are more hazardous than those occurring in the lumbar region. Generally, the nearer the broken vertebra is to the roots of the phrenic nerves, the greater the danger becomes. In like manner, fractures of the lumbar and dorsal vertebræ, attended by displacement of the fragments and injury of the spinal cord, with paraplegia, are less speedily fatal than those of the cervical vertebræ. Moreover, in all parts of the spinal column, fractures of the vertebræ which are not complicated with injury of the spinal cord, are less dangerous than those which are attended by such injury.

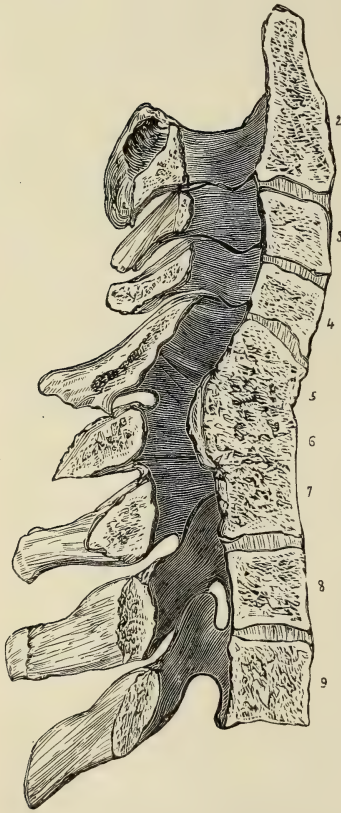
The proximate causes of death in fractures of the spinal column, aside from pithing the spinal cord by the odontoid process, or by some fragment of the first three vertebræ, are the following: (1) intra-thecal extravasation of blood; (2) spinal meningitis; (3) ascending myelitis; (4) intra-spinal abscess, that is, an accumulation of purulent matter formed between the theca vertebralis and the bone; and (5) trophic disorders of the paralyzed parts, for example, gluteal eschars or acute bed-sores, with vesical and renal inflammations. These trophic disorders arise quite as much, perhaps even more, from the inflammatory disorganizations of the spinal cord which result from vertebral injuries, than from the traumatic lesions of the cord itself. Now, the gravity of the prognosis is always increased by the appearance of any signs of these various complications or accidents which constitute the proximate causes of death in the cases of vertebral fracture which end badly. Hence, the appearance of spinal paralysis in cases where it did not attend the original injury, or the passage of a partial paralysis into a complete paraplegia, but, particularly, the creeping steadily upward of a spinal paralysis that began in the legs, until the sensibility as well as the voluntary motility is destroyed as far as the nipples, or even the root of the neck, are all signs of extreme danger to life. The persistence of an abnormally high or low degree of body-temperature, and the flushing of the face which results from vaso-motor paralysis, especially if it be combined with dyspnoea, are fatal symptoms, and they likewise denote that the end is nigh. Priapism is an unfavorable symptom, but not always a fatal one.

On the other hand, the prognosis becomes less unfavorable when the symptoms of spinal paralysis grow less strongly marked, when the patient recovers

the power to micturate at will and to defecate naturally, when the respiratory movements, after being solely diaphragmatic, are again performed in a normal manner, when the sensibility and power of voluntary motion are seen to be returning to the paralyzed parts in general, etc. These signs, and others like them, are of good omen in all cases of spinal injury.

Fractures of the cervical vertebræ, if attended by symptoms which show that the spinal cord is injured, are almost always fatal. Several illustrative cases, as well as the causes of the great fatality of these lesions, have already been presented and described with sufficient minuteness of detail to answer all practical purposes. Of ten patients with fracture of the five lower cervical vertebræ, whose cases are collected by Professor Hamilton,¹ one survived

Fig. 863.



Showing a vertical section of the first nine vertebræ, excepting the atlas, from Mr. Hilton's case, in which there were fractures of the bodies of the fifth, sixth, and seventh cervical vertebræ, and the patient survived for fourteen years. The fractured vertebræ are seen to be consolidated by bone, both at their bodies and at their arches.

part :—John Carter, aged 21, on a Sunday morning in May, 1836, fell from a tree, about forty feet, upon his back, or, more probably, upon his head. He was stunned to un-

twenty-four hours, one eleven days, one fifteen weeks and six days, one four months, and only one, whose case I shall presently relate and illustrate with a wood-cut, lived fourteen years. To the sad rule which is thus portrayed there are, however, some notable exceptions on record, for example :—

Ollivier d'Angers² reports the case of a man who injured his neck by falling backward from a wheel, and striking the ground with it. There was paralysis, with mobility about the seventh cervical vertebra. After two months the paralysis began to diminish under general treatment. At the end of three years he was nearly well. (Ashhurst.)

Again, the same author³ relates the case of a carman, aged 21, injured by falling and striking the back of his neck. There was paralysis, etc. In two and a half months he recovered. Six months after the original accident his neck was broken afresh, by being pushed down while he was taking a long walk. There was sudden paralysis, etc.; and in thirty-four days death ensued. *Dissection* showed that the original injury consisted of fractures of the fourth and fifth cervical vertebræ, the body of the fourth having been broken; and that the callus had been fractured by the second fall. (Ashhurst.) Had there been no second accident, this man (there is but little doubt) would have recovered entirely from the original fractures.

Mr. Hutchinson,⁴ likewise, reports two cases, the one being that of a woman and the other that of a man, in which there was fracture of the lower cervical vertebræ, with partial paralysis, and yet both patients recovered.

Mr. Hilton has reported a case, with a wood-cut (Fig. 863), in which there were fractures of the fifth, sixth, and seventh cervical vertebræ, with complete paralysis from the neck downward, and yet the patient survived in a paralyzed condition for fourteen years, ultimately perishing from injury of another

¹ Fractures and Dislocations, p. 155.

³ Ibid.

² *Traité des Maladies de la Moelle Épinière*, t. i.

⁴ *London Hospital Reports*, vol. iii. pp. 347, 348.

consciousness, and completely paralyzed up to the neck as to both sensation and voluntary motion. The neck was very stiff, but no irregularity of the vertebræ could be perceived. He was treated by venesection and by cupping the back of the neck, "and, using proper remedies, a capability of moving the head gradually returned." The bladder was paralyzed, and catheterization required. After some weeks, the ability to micturate at will appears to have returned, and he was able to defecate by taking senna. After some weeks, also, "a certain amount of motion was restored to the head and neck, and sensibility to the same extent; but the rest of the body remained perfectly paralyzed and insensible." Many years afterward, it was noted that there was nothing abnormal to be felt about the spine; that no costal movements occurred during respiration; that there was perfect loss of voluntary motion in the lower and upper extremities, with almost perfect loss of sensation in the same; that his bowels were never moved without medicine (senna); and that his urine was very offensive when he caught cold, at other times not so offensive, but always a little so. His urine was acid. He felt a distinct pain in the bowels occasionally, and now and then an aching in the loins. When sick, he vomited with great difficulty. Erections of the penis were frequent, and lasted a quarter of an hour, with slight escape of seminal fluid occasionally. Fourteen years after the original injury, he was upset whilst being dragged about in a little four-wheeled cart by a boy, and, as he could not put out his hands to save himself, he fell to the ground with great violence; this led to some chest affection, which caused death in a few days. A complete autopsy could not be obtained; but the specimen was procured, which is portrayed in the accompanying wood-cut (Fig. 863). In it the bodies and arches of the fifth, sixth, and seventh cervical vertebræ are seen blended together by bone. The body of the sixth vertebra is displaced and projects backward into the spinal canal. The intervertebral substances have disappeared, but their outlines are still marked, and their places occupied by bone. Every one must admire the perfect union which has taken place by new bone; and if nature could have done as well with the spinal cord, this patient might have perfectly recovered.¹

Mr. Bryant, likewise, mentions the case of a gentleman, aged 29, whom he saw, November 25, 1870, with complete paralysis of the whole body below the fifth cervical vertebra, caused by a fall upon the neck, who was still alive in 1877, breathing solely by the diaphragm;² exactly as the man, whose case Mr. Hilton has reported, did for fourteen years, and until he perished in consequence of another accident.

These examples of recovery from cervical fracture have been presented in order to encourage surgeons to give every possible care and attention to the treatment of cervical injuries attended by paralysis, with the hope of obtaining the same happy result.

Recoveries from fractures of the dorsal and lumbar vertebræ have been recorded in so many instances, that these lesions now are often, perhaps generally, considered to be quite amenable to appropriate treatment. This results in great part from the fact that the spinal cord, in adults, not only ends in a rounded point at the first or second lumbar vertebra, but also becomes, in the lower part of the dorsal region, a leash of nerves, the cords of which are wrapped in a strong fibrous covering; and, for this anatomical reason, being able to freely slide on each other, they glide out of the way of the displaced fragments of broken vertebræ, and thus escape serious damage.

As for successful examples, Mr. Hulke³ records a very interesting case of recovery from fracture of a dorsal vertebra. Baron Dupuytren⁴ gives two cases observed at the Hôtel-Dieu. The first was that of a mason, aged 28, who, by a fall, fractured his spinal column about the tenth dorsal vertebra. Paralysis came on in two days. He was treated by cupping, by rest in bed, etc.; and, in two months, he recovered. The second case was that of a washerwoman, who fell from a second story upon her feet, and then upon her back. The tenth, eleventh, and twelfth dorsal vertebræ projected backward, and her right lower extremity was paralyzed. She was treated by bleeding, by rest in bed, etc.; and, in four months, she recovered.

¹ Op. cit., pp. 65-67.

² Medical Times and Gazette, February, 1874.

³ Op. cit., pp. 203, 204.

⁴ Diseases and Injuries of Bones, Sydenham Society's translation, pp. 356, 357.

Five cases of vertebral fracture in the lower dorsal and lumbar regions, with paralysis, are recorded in the London Hospital Reports.¹ Recovery in every instance was obtained, in from four to six months.

Dr. Lente² relates the case of a man, aged 20, injured by falling from a roof upon his buttocks and loins. There was fracture of the third or fourth lumbar vertebra, with paralysis. Bed-sores and exfoliation from the fifth lumbar vertebra followed. Afterward he improved. At the end of four years he could not quite stand alone; but he went about the country as a peddler. Dr. Lente likewise reports another case of the same sort, in which recovery took place, and the man was able to work again.

Professor Agnew³ mentions a case seen by himself two years before, in which the twelfth dorsal vertebra was fractured, with complete paralysis of the lower extremities. The patient recovered sufficiently to make a sea-voyage, and was still living.

Professor Ashhurst⁴ has collected from the Pennsylvania Hospital Record the following instances of fracture of the dorsal or lumbar vertebræ, in each of which a more or less complete recovery occurred: (1) A harness-maker, aged 37, injured his back by falling from a roof. The twelfth dorsal vertebra was fractured, and its spinous process projected backward. He recovered in ninety-four days, though slight deformity and paralysis of the right limb still remained. (2) A sailor, aged 40, was injured by falling upon his back. A dorsal vertebra was fractured, with backward projection. In seventy-seven days he recovered, excepting slight deformity. (3) A seaman, aged 25, was injured by falling from a third story. He was found to have a contusion, a scalp-wound, and pain in the back. After some days, projection of the twelfth dorsal vertebra backward was observed, but no paralysis. In sixty-eight days he recovered, and slight deformity only remained. (4) A laborer, aged 55, fell against a fence. He had contusion of the brain, fractures of the first and second lumbar vertebræ, with backward projection, retention of urine followed by incontinence thereof, and paralysis. At the end of three hundred and thirty-three days the power of motion had become, in some degree, restored, but the deformity remained. (5) A laborer, aged 69, fell from a third story window, and fractured the vertebræ at the dorso-lumbar junction. He recovered in one hundred and twelve days, notwithstanding that the prognosis of his case was complicated by an attack of mania a potu. (6) A laborer, aged 20, fell from a tree, and fractured a vertebra. In seventy-seven days he recovered.

Mr. Syme⁵ reports the case of a man, aged 32, who fell, striking on his buttocks, and thus injured his spine. The vertebræ projected at the dorso-lumbar junction; there were also pain and spinal paralysis. On the second day he began to improve; and in forty days he recovered, so as to walk with a cane.

Mr. Stanley⁶ had the case of a sawyer, aged 23, who fell twenty-four feet. There were pain and ecchymosis in the back, and a fractured calcaneum. After a week, projection of the twelfth dorsal and first lumbar vertebræ was observed. He recovered in two months. There were no spinal symptoms. (Ashhurst.)

Mr. T. Wakley⁷ reported two cases of lumbar fracture, with recovery. The first was that of a man, aged 34, crushed in driving through an archway. There were projection of the second lumbar vertebra and spinal paralysis. In thirteen weeks he was able to walk with a cane. In four and a half months he recovered, and resumed his occupation. The second was that of a carriage-maker, aged 31, who received a blow on the back from a ton-weight. There was projection of the second and third lumbar vertebræ, with pain, and spinal paralysis. He recovered in five and a half months. He walked, but not very well.

Sir Charles Bell⁸ relates a case of recovery from fracture of the spine, treated by Mr. Joberns. The patient was a young woman, aged 18, thrown from a second story window on her back. There was great tumefaction over the lower dorsal vertebræ; the spinous

¹ Vol. iii. pp. 326, 346.

² American Journal of the Medical Sciences, October, 1857, p. 361.

³ Op. cit., vol. i. p. 828.

⁴ Edinburgh Medical Journal, vol. xxxvii.

⁵ Lancet, 1849.

⁶ Op. cit., pp. 108-119.

⁷ Ormerod, Clinical Collections.

⁸ Op. cit.

processes were crushed, but there was no paralysis; there was a wound over the sacrum. She was treated by rest, etc., and in ten and a half months recovered. She lay for eight months with body bent and legs drawn up; but had regained the erect posture when discharged.

Dr. Dorrance¹ relates the case of a cooper, who was struck by a falling tree. There were fracture and backward projection of the eleventh dorsal vertebra, with spinal paralysis. He recovered in one year, and resumed his occupation; but slight deformity remained.

Mr. Shaw² reports four cases of vertebral fracture in the dorso-lumbar region, but without paralysis, in which each patient recovered sufficiently to resume work again.

But Mr. Teale³ has recorded the most interesting case of all. In it the body of the second lumbar vertebra was crushed, and there was spinal paralysis; still, the patient made a complete recovery, but with angular curvature, and survived twelve years in good health, when, having died of typhus, the diagnosis was verified by an autopsy. The patient was an adult man. His injury was caused by a beam falling across his back. When admitted to the infirmary, all the usual signs of vertebral fracture, with displacement, were present in the lumbar region. He was unable to move his legs; and, for three weeks after admission, required the use of a catheter to empty his bladder. Sensation was not wholly lost at any time. At the end of three weeks, he micturated without assistance, and could walk across the floor with the aid of a stick. Six weeks after the accident, he walked well, and was discharged cured. A projection of the spinous process of the first lumbar vertebra had been felt from the first, and was still present when he left the hospital. After twelve years' good health, he was again admitted for typhus fever, of which he died, and then the specimen was obtained. It showed an obtuse bend forward in the upper part of the lumbar region. The body of the second lumbar vertebra had been crushed; and, at the anterior border, had not more than half the normal thickness. Anchylosis had occurred between the first and second lumbar vertebra.

Some seven or eight additional cases of fracture of the dorsal and lumbar vertebræ, in each of which recovery ensued, will presently be mentioned or referred to under the head of *treatment*.

In France, besides the cases of Dupuytren mentioned above, several successful examples belonging to the same category have been reported, two by Bégin,⁴ four by J. Cloquet,⁵ and at least one by Malgaigne.⁶ In most of these cases there was complete spinal paralysis, but it gradually disappeared; and, after some months, or even years, of treatment, recovery ensued. Many other successful examples of the same sort, if time permitted, could doubtless be collected.

Numerous other cases of vertebral fracture, in the dorsal and lumbar regions, in which the patients survived a long time, notwithstanding that the spinal cord was severed, or that the broken bones were much displaced, might likewise be collected. But few of them, however, will be presented.

Professor Hamilton⁷ mentions a case under Mr. Key's care, in which the first lumbar vertebra was fractured. The patient, a boy, survived the accident for one year and two days. *Necroscopy* showed bony union, and the spinal cord completely divided.

Sir A. Cooper⁸ gives the case of a man, aged 28, under Mr. Harold's care, with fractures of the first and second lumbar vertebræ caused by a mass of chalk falling upon him. There was spinal paralysis, which affected the bladder and intestines as well as

¹ American Journal of the Medical Sciences, O. S. vol. xvi.

² London Med. Gazette, vol. xviii. p. 936; Trans. Patholog. Soc. London, vol. iii. p. 420.

³ Brit. and For. Medico-Chirurg. Review, October, 1869, and New Syd. Soc. Retrospect, 1869-70, pp. 247, 248.

⁴ Œuvres Chirurg., t. ii.

⁵ Dictionnaire de Médecine, t. ix.; Maisonnabe, Journal des Difformités, t. i.

⁶ Op. cit., t. ii.

⁷ Op. cit.

⁸ Dislocations and Fractures of Joints.

other parts. He died from a slough (bed-sore) on the nates, one year and eleven days after the accident. *Necroscopy* showed union by bone, and the spinal cord nearly severed by a fragment of bone which had pierced the theca vertebralis.

An instance of dislocation of the first, and fracture of the second lumbar vertebra, in which the patient survived the lesion for three and one-half years, and the specimen from which was exhibited at the Pathological Society of London by Mr. W. Wagstaffe, has already been mentioned above.

Professor Agnew¹ gives, with a wood-cut illustrating the lesion, the case of a young man who was caught at the Kensington Depot, Philadelphia, between the platform and a car, in such a way as to fracture the spinal column in the mid-dorsal region, with comminution; yet, notwithstanding that the spinal cord was completely divided by a permanently displaced vertebra, he survived the accident for six months, and perished at last from sloughing of the nates.

Le Gros Clark² relates a very instructive case in which the fourth lumbar vertebra was fractured through both pedicles, while its processes were all comminuted, and its ligaments ruptured, so that the body of this vertebra was dislocated forward and downward, and took up a new position in front of the fifth lumbar vertebra, the upper and lower surfaces of both vertebræ being in the same planes; although the injury was at first attended by complete paraplegia, the sensibility was restored entirely, and the motility partially, in five weeks. Death ensued in the seventh week, in consequence of sloughing or acute bed-sores. A highly suggestive feature of this case is the fact that, notwithstanding the enormous displacement which occurred between the fourth and fifth lumbar vertebræ, the spinal cord was not much injured, and the paraplegia soon passed away.

The following is in the same vein: "In one case," says Mr. Hutchinson, "I found the trunks composing the cauda equina lifted a third of an inch on a bridge of bone, formed by the displacement of a fractured lumbar vertebra; but they were in no degree compressed, and, excepting a little ecchymosis in their pia mater, showed scarcely any trace of injury."³

A very practical inference from facts such as these is that, however great the displacement and the paralysis may be in cases of fracture or dislocation of the spinal column, we have no right to assume at the outset, during life, that the spinal cord is irreparably or even severely injured thereby.

These clinical histories and accounts of autopsies have been presented, aside from their general value, with a special intent to show that, in cases of vertebral fracture and dislocation, the surgeon is justly entitled to approach the question as to what their treatment should be, with something more of hope for obtaining a happy issue by appropriate treatment, than most textbooks on surgery would seem to encourage.

Treatment of Fractures of the Vertebræ.—The successful management of cases in which the spinal column is fractured, chiefly depends on the following points: (1) On preventing those intra-theal extravasations of blood which destroy life by compressing the spinal cord. (2) On preventing or subduing spinal meningitis, and abscess between the theca vertebralis and the bone. (3) On preventing or subduing ascending myelitis, and all inflammatory disorganizations of the spinal cord. (4) On conducting the bed-sores, and the vesical and renal inflammations, which are apt to complicate such cases, to a favorable issue.

The victim should be carefully picked up, and carried from the scene of the accident home, or to a hospital, on a stretcher, on one extemporized from a settee or a shutter, etc., or in an ambulance, every precaution being taken against increasing the injury of the spinal cord, that was mentioned while

¹ Op. cit., vol. i. pp. 827, 828.

² British Med. Journal, October 3, 1868.

³ London Hospital Reports, vol. iii. p. 360.

describing the treatment of luxations of the vertebræ, especially if the fracture be seated in the cervical region. The surgeon should make his diagnosis as complete as possible, at his first examination of the case, in order to avoid the doing of harm by moving the patient to make any subsequent examinations. The patient should be placed on a water-bed; but, if it is not practicable to do that, upon a soft, thick hair-mattress. The fractured vertebræ should then be "set," that is, their fragments should be restored to as nearly a normal position as possible: (1) by attending to the patient's posture in bed, for sometimes a *dorsal* or even an *abdominal decubitus* will quite remove the deformity, as well as greatly lessen the patient's sufferings; (2) by employing extension and counter-extension (whenever necessary), made with the hands of skilled assistants, at the same time cöaptating the fragments with the hands; and (3) by applying extension continuously with weights, in cases where there is shortening of the spinal column. The following examples are in point:—

Malgaigne¹ gives the case of a clerk, aged 22, who was treated by himself at the Hôpital des Cliniques, in 1843. The man had fallen from a second story, alighting on his heels and buttocks. Both calcanea were fractured. The spinous process of the twelfth dorsal vertebra was also fractured, and displaced toward the right side. There was paraplegia with great pain in the back on motion, and it was thought that a lumbar vertebra was likewise broken. The patient was treated by rest in bed alone, and the paralysis gradually passed away. When he got up, the displaced spinous process had resumed its proper position.

In some cases of vertebral fracture, the fragments readily subside into a normal position when the patient is confined to bed in *dorsal decubitus*. This doubtless occurred in the example just mentioned. In other instances the deformity has been removed by making the patient *lie on his belly*, and a complete cure has been obtained by making him keep that posture until the fracture has united.

Sir B. Brodie² mentions the case of a boy, who was injured in the lower part of the back. There were fracture and displacement of the third and fourth lumbar vertebræ, and spinal paralysis. Attempts at reduction were made, and proved partially successful. After the first month, voluntary motion, as well as sensation, gradually returned. At the end of three or four months the patient was much relieved.

Mr. Higginson³ mentions a case in which there was fracture, with displacement, of a dorsal vertebra. The patient was treated by extension, and recovery ensued.

Mr. Luke⁴ relates the case of a man having fracture of the seventh dorsal vertebra. The displacement was corrected by making extension, and the reduction was accompanied by an audible sound. Erysipelas, however, supervened, and caused death seven days after the accident. At the *autopsy*, the spinal cord was found to be softened and disorganized, and to contain purulent matter.

The fatal issue of this case does not appear to have been in even the least degree due to making extension, and effecting reduction of the displaced fragments of the seventh dorsal vertebra. Moreover, I have not found a record of any case of spinal fracture in which the efforts at reduction proved at all hurtful. But reduction by extension is not to be employed in every instance; certainly not in cases where the deformity can be removed by adjusting the patient's posture in bed. Reduction by extension, however, is allowable when much deformity, and especially shortening, of the spinal column exists; and, likewise, when severe pain arises from the fragments of bone pressing upon

¹ Treatise on Fractures, etc., p. 342. Packard's translation.

² Medico-Chirurgical Transactions, vol. xx. p. 159.

³ British Medical Journal, 1862.

⁴ Lancet, 1850.

the spinal nerves. Bryant has seen several cases in which marked relief has been afforded by this means;¹ and the records of surgery contain many others. When practised with discretion, the reduction of vertebral fractures by extension is undoubtedly a valuable mode of treatment. When the displacement shows a decided tendency to recur, and likewise when there is marked shortening, it will often be advisable to make the extension continuous by means of weights attached to the patient by strips of adhesive plaster, and suspended from the head of the bed, in the manner already described while discussing the treatment of vertebral dislocations.

When there is much pain at the seat of fracture, or in the terminal branches of the spinal nerves which issue from the spinal column through the intervertebral foramina at the seat of fracture, opium or morphia must be administered in full doses, and at sufficiently short intervals to subdue the pain and keep it in subjection. Afterward, the patient should be kept moderately under the influence of morphia as a precautionary measure against consecutive spinal meningitis and myelitis, and, by the way, opium or morphia thus administered, is one of the most efficient agents for this purpose in the *materia medica*.

If, in a few hours after the accident, signs of compression of the spinal cord from extravasation of blood within the theca vertebralis should appear, the fluid extract of ergot should be given in full doses, and at short intervals, and an ice-bag should be applied over the spinal column, with a view to suppress the bleeding.

Efforts to abate the inflammation of the injured structures at the seat of fracture, and thus to prevent the occurrence of consecutive meningitis and myelitis, should be made by abstracting blood with leeches, by applying cold lotions, and by keeping the fractured bones as nearly immovable as possible. The attentive reader, doubtless, has already noted that, in many of the successful cases of spinal fracture related above, blood was abstracted, either generally by venesection or locally by cupping, that cooling lotions were applied to the injured part, and that the patient lay quietly in bed.

Should spinal paralysis begin one, or two, or more days after the accident, or should a pre-existing paralysis then begin to increase or invade new parts, or should any other symptoms denoting the presence of spinal meningitis or myelitis appear, the surgeon should seek to control the inflammation of the membranes and substance of the spinal cord, by administering ergot and potassium iodide in full doses, and by insisting on having perfect rest for the injured parts, if this remedial measure have not already been thoroughly enforced.

Should there be inability to micturate, catheterization must be employed morning and evening, and oftener if necessary. Should there be constipation, the bowels must be moved at appropriate intervals by giving senna, and by administering enemata. The alimentation of the patient must be attended to, and a nourishing but easily digestible diet allowed. Every possible precaution, in the way of cleanliness, etc., should be taken against the formation of bed-sores.

In regard to the use of mechanical contrivances to keep the broken parts of the spinal column in apposition, and free from all motion, thus performing the offices that splints do in fractures of the extremities, it is obvious that if these ends could be accomplished by any mechanical contrivance, the patient's recovery would be considerably expedited, and the risk of consecutive meningitis and myelitis would be considerably lessened by employing it. As such an apparatus, the plaster-of-Paris jacket, devised by Professor Sayre, has

¹ *Op. cit.*, p. 204.

recently been applied in a number of instances. Professor König, of Göttingen, has an article in No. 7 of the *Centralblatt für Chirurgie*, for 1880, on the application of the "Thorax Gypsverband" for fractures of the spine, and recounts therein three cases, in all of which there was considerable displacement, with but very slight, if any, nervous symptoms. In each of these three cases, the patient was suspended sufficiently to correct the deformity, and a long jacket reaching down to the trochanters was put on; and every one of them made a complete and rapid recovery. The cases were all recent and simple. Dr. W. Wagner, however, reports two similar cases in which, after the application of the jacket, intense pain in one instance, and paralysis in the other, appeared in the lower extremities, so that it was necessary to remove the apparatus. In one case it was reapplied subsequently, with comfort to the patient. Both patients recovered.¹ Possibly, the failure of the first application of the jackets, in the last two instances, was due to not exactly reducing the displacement of the fragments prior to fitting the jackets, so that the apparent want of success was caused not so much by the apparatus itself, as by the failure to apply it properly. At all events, no great harm was done, for recovery was not prevented in either instance. Obviously, this plan of treatment is not appropriate for cases in which there are bed-sores, or in which inflammatory disorganization of the spinal cord is already far advanced. But, for simple, uncomplicated cases of spinal fracture, in which the injury is recent, it seems likely to prove of great service, and undoubtedly is in improvement on any of the old methods of treatment now in vogue for such cases.

When the body-temperature rises to 102° F., or more, and persists, what is to be done? Possibly, in cases where the mercury stands at 102° or 103°, the trunk and extremities may be sponged with diluted alcohol, from time to time, with advantage; and, in cases where it rises to 105°, or more, and the extinction of life is threatened by the body-heat itself, it may be advisable to use the "cold-water pack," carefully noting its effects, meanwhile.

When the body-temperature sinks below the normal limit, whether the coldness be confined to the paralyzed parts or diffused over the whole system, care must be taken in applying artificial heat—*e. g.*, bottles of hot-water, heated bricks, or sad-irons, etc.—lest the parts to which they are applied become burned from the negligence of the attendants.

GUNSHOT INJURIES OF THE VERTEBRÆ.

Soldiers are sometimes killed in battle by gunshot injuries of the cervical vertebræ. Dr. Otis² reports two instances of this sort that he had himself seen, in which "the ball lodged in the cervical spine," among the bodies of those lying dead on the field of battle before New Berne. Gunshot injuries of the spinal column may thus quickly destroy life: (1) By dividing or crushing the spinal cord above the third cervical vertebra, that is, above the roots of the phrenic nerves, thereby completely and instantaneously arresting the respiratory movements; and (2) By opening the vertebral artery, in some part of its course within the canal formed by the vertebral foramina in the transverse processes of the six upper cervical vertebræ.

Mr. Shaw³ has placed on record, together with a wood-cut, the following example, which admirably illustrates the first of these two modes in which

¹ Medical Times and Gazette, December 18, 1880.

² Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 603.

³ Holmes's System of Surgery, vol. ii. p. 395.

gunshot lesions of the spinal column may destroy life with great suddenness:—

A gentleman was wounded by a pistol-shot in the back of his neck while lying asleep on his side; his mistress, who was awake at the time, stated that he did not stir a limb nor move in any way, although the report was loud. Death, therefore, must have been instantaneous. *Necroscopy* showed that the missile entered at the median line, passed horizontally forward between the arches of the atlas and the axis, severed the spinal cord, and stuck fast in the odontoid process near its base, having fissured the same. The specimen is preserved in the museum of Middlesex Hospital.

In regard to the second of these two modes in which life may be suddenly destroyed, it should be stated that gunshot fractures, involving any of those transverse processes of the cervical vertebræ through whose foramina the vertebral artery runs, may readily lay the artery widely open, and that the primary hemorrhage therefrom would soon prove fatal; certainly, death would ordinarily ensue before a man thus wounded could be removed from a field of battle. In this connection it may be well to state also that gunshot fractures of these transverse processes are not unfrequently attended by *secondary hemorrhage* of a fatal character, which usually appears some ten or twelve days after the casualty has occurred.

For instance, Baron Dupuytren¹ mentions the case of a carpenter, aged 31, who received a gunshot wound of the face and neck. The ball entered his nose. The wound did well for ten days, when secondary hemorrhage set in, and caused death. *Necroscopy* showed that a transverse process of the second cervical vertebra was fractured, and that the hemorrhage arose from the corresponding vertebral artery.

Usually, in such cases, the laying open of the artery, so that the blood may issue therefrom, is caused either by the separation of a slough consisting of the tissues which have been bruised by the missile in its passage, or by the perforation of the arterial tunics by an ulcerative process. In the following instance, however, it was caused by the beating of the vertebral artery itself against a sharp fragment of the transverse process which had been fractured:—

Samuel S. was wounded at the battle of Williamsburg, May 5, 1862, by a musket-ball which entered his face to the left of the symphysis of the inferior maxilla, smashed that bone, and carried away several teeth, with a part of the tongue and of the posterior wall of the pharynx, and lodged. He had extreme dysphagia. On the 13th, the ball and several teeth were removed from an abscess above the clavicle. On the 16th, copious hemorrhage from the original wound occurred, which was arrested by tying the common carotid artery under ether. Seven days after that, a fresh hemorrhage set in from the aperture through which the missile had been extracted; an unsuccessful attempt was made to find the bleeding vessel. He died on the same day (May 23) of anæmic exhaustion resulting from the hemorrhage. *Necroscopy* showed that a transverse process of the third cervical vertebra had been fractured by the ball, and that the vertebral artery had rubbed against a spiculum thus produced until it was worn through; hence the secondary hemorrhage arose.² The first hemorrhage, doubtless, sprang from some branch of the external carotid artery in the face, mouth, or throat, which had been injured by the missile, and, therefore, it was possible to suppress it by ligaturing the common carotid artery.

GUNSHOT CONTUSIONS OF THE SPINAL COLUMN were, I believe, first mentioned by Dr. Louis Stromeyer, while writing from his experience as surgeon-in-chief of the Schleswig-Holstein army, in 1849. He says:—

“In two cases the cervical vertebræ were contused by bullets which entered on the outer side of the sterno-mastoid muscle, and likewise bruised the brachial plexus of

¹ Op. cit.

² Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 355.

nerves; the paralysis of the corresponding arm was at first so complete that I considered the brachial plexus must have been torn by the bullet; but, gradually, sensation and motion almost fully returned.

"In a case of contusion of the cervical vertebræ by a similar shot, there has remained till this moment—a period of four months—stiffness and pain in the neck on motion. In all these cases small sequestra escaped."¹

In cases where the vertebræ are contused by gunshot missiles, the bodies are the portions thereof which are usually found to be affected. Indeed, I am not acquainted with any instance where this lesion was confined to the vertebral apophyses.

The consequences of gunshot contusions of the vertebræ are: 1, *necrosis* of the bruised parts; 2, *caries* of the same; and 3, *inflammation* of the injured bone, which may spread to the membranes and substance of the spinal cord.

1. As examples of necrosis, Stromeyer's three cases just mentioned above, in each of which small sequestra escaped from the wound, may be appropriately cited.

2. As an instance of caries arising from this cause, the following abstract, together with the accompanying wood-cut (Fig. 864), may be presented:—

Private George A. A., 20th New York Volunteers, aged 40, was wounded at Gettysburg, July 2, 1863, by a conoidal ball, which fractured the right lower jaw, struck the bodies of the sixth and seventh cervical vertebræ, and lodged. It is said that the missile was afterward ejected by the patient from his mouth. But pyæmia supervened and caused death. It is stated that the patient had dyspnœa, but no paralysis; that he walked about until a few days before his death, which occurred on the 21st (nineteen days after the casualty occurred); that he had complained only of a slightly uneasy feeling in the neck when turning his head; and that the injury of the cervical vertebræ was not suspected during life. *Necroscopy* showed that the bodies of the sixth and seventh cervical vertebræ were carious in the parts where they had been struck and bruised by the missile (see Fig. 864), and that a fissured fracture extended through the body of the sixth vertebra. Pyæmic lesions, too, were found; that is, the right lung was in a condition of recent pneumonia, and filled with a multitude of small abscesses, the presence of which fully accounted for the occurrence of dyspnœa. The œsophagus, the trachea, and the bronchial mucous membrane were inflamed.² In this case, the contusion of the cortex or outer lamella of the body of the sixth cervical vertebra was complicated by a fissured fracture of the vertebral body; the body of the seventh cervical vertebra, however, was not fractured, but only bruised and carious. The carious condition of both vertebræ is well shown in Fig. 864. The specimen which it represents is preserved in the Army Medical Museum.

3. The spreading of inflammation from the injured bone to the membranes and substances of the spinal cord, with a fatal result in consequence thereof, may be illustrated in a useful manner by presenting another example taken from Stromeyer:—

"In a case where a bullet, entering laterally, severely bruised the third and fourth cervical vertebræ, and was not extracted, death followed in consequence of the advance of inflammation into the spinal cord and brain; there was at first palsy of the arm

Fig. 864.



Showing caries of the last two cervical vertebræ caused by gunshot contusion. (Spec. 1867, Sec. I, A. M. M.)

¹ Stromeyer on Gunshot Fractures, translated by S. F. Statham, pp. 37, 38. Am. ed.

² Medical and Surgical History of the War of the Rebellion, First Surgical Vol., p. 431.

belonging to the injured side ; it was followed by incomplete paralysis of all the limbs, ending in stupor. Antiphlogistic treatment had been entirely neglected.”¹

Etiology.—The impact of gunshot missiles upon the bodies of the vertebræ causes contusion thereof only when the force of the missiles is nearly spent, on the one hand, or when the direction of their flight is very oblique, so that they strike a glancing blow, on the other hand. When endowed with less force, they do no injury ; and with greater force they produce fractures.

Treatment.—The principal indication in the therapeusis of gunshot contusions of the spinal column is to prevent the occurrence of inflammation in the injured bone, and the spread of the inflammatory process therefrom to the meninges and medulla spinalis. This can best be accomplished by the extraction of all foreign bodies from the wounds, by the employment of antiseptic dressings, by thorough drainage by means of appropriate tubes, inserted for the purpose whenever necessary to prevent the collection of purulent secretions, and by enforcing perfect rest of the injured spinal column.

GUNSHOT FRACTURES OF THE VERTEBRÆ are caused by the impact of shell-fragments, spent cannon-balls, and small-arm missiles, but chiefly by the impact of the last named, after they have penetrated the integuments and other structures that cover the spinal column at the place of injury, or have reached it by passing through the great cavities of the body and organs which lie in front. In some rare instances, however, the fractures produced by cannon-balls and shell-fragments are simple, the integuments covering them being unbroken. Gunshot fractures of the vertebræ are usually comminuted in character as well as compound ; and they are very often complicated with injury of the spinal cord and other important organs.

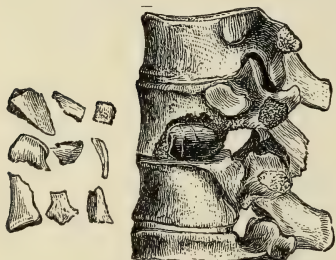
For descriptive purposes, gunshot fractures of the vertebræ may advantageously be divided into two classes—namely, those which are restricted to the apophyses, and those which involve the vertebral bodies also. The former are sometimes, perhaps frequently, unattended by injury of the spinal cord ; the latter are but seldom uncomplicated with such injury. The former, too, are less fatal, as a rule, than the latter.

The chief characteristics pertaining to gunshot fractures of the spinal column, in general, are well shown by the following abstract, and by the wood-cut (Fig. 865) which accompanies it:—

Showing a gunshot fracture of the body and left transverse process of the ninth dorsal vertebra. The missile and nine fragments of bone are also shown. (Spec. 5738, Sect. I, A. M. M.)

through the left lung, and onward through the body and left transverse process of the ninth dorsal vertebra ; it lodged in the subcutaneous tissue of the back, from which it was extracted, together with some small fragments of bone, through a small incision. The patient was paralyzed below the middle. He died of traumatic pericarditis and pneumonia, four days after the wound was inflicted.² The deep groove across the spinal column which was punched out by the missile, and the comminution of the injured bone, are well depicted. The occurrence of paraplegia, of course, denotes that the spinal cord was also injured.

Fig. 865.



¹ Op. cit., p. 38.

² Circular No. 3, S. G. O., August 17, 1871.

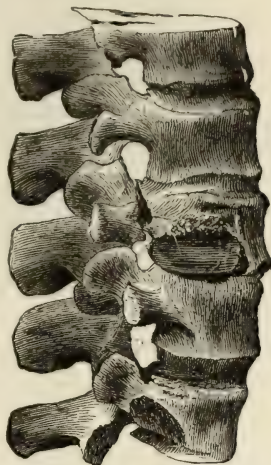
Sometimes the missile punches a ragged hole through the vertebral column obliquely from behind forward, and emerges from the body of a vertebra, having crushed the spinal cord in its course; as, for instance, it did in a specimen which the writer contributed to the Army Medical Museum, and which is represented by the annexed wood-cut (Fig. 866):

The missile entered through the left intervertebral foramen between the third and fourth lumbar vertebræ, chipping the superior articular process of the fifth and the adjacent portion of the spinous process of the fourth, and fracturing the left transverse process of the fourth, passed obliquely forward and toward the right, and emerged from the body of the third lumbar vertebra on its right side. The patient survived long enough for incipient caries to appear in the injured bones.¹

In the celebrated and historical case of President Garfield, the ball penetrated the first lumbar vertebra in the upper part of the right side of its body (Fig. 867):—

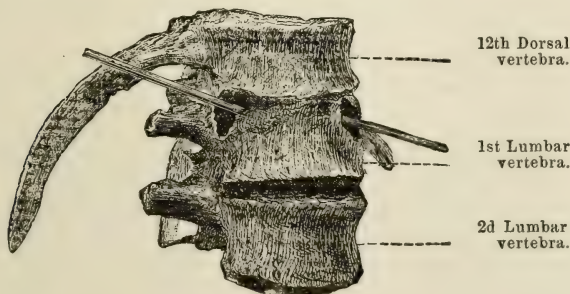
The aperture by which it entered involved the intervertebral cartilage next above, and was situated just below and anterior to the intervertebral foramen, from which its upper margin was about one-fourth of an inch distant. Passing obliquely to the left and forward through the upper part of the body of the first lumbar vertebra, the bullet emerged by an aperture, the centre of which was about half an inch to the left of the median line, and which also involved the intervertebral cartilage next above (Fig. 867).

Fig. 866.



Showing gunshot fracture of the third lumbar vertebra with the missile (a conoidal musket-ball) attached. (Spec. 2532, Sect. I, A. M. M.)

Fig. 867.



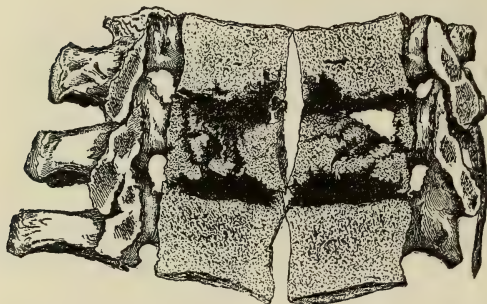
Showing the hole made by the missile (a conoidal pistol-ball) through the body of the first lumbar vertebra, in the case of President Garfield. A probe penetrates each orifice. $\frac{3}{4}$.

The cancellated tissue of the body of the first lumbar vertebra was very much comminuted, and the fragments were very much displaced. Several deep fissures extended from the track of the bullet upward into the lower part of the body of the twelfth dorsal vertebra. Others extended downward through the first lumbar vertebra into the intervertebral cartilage between it and the second lumbar vertebra. Both this cartilage and that next above were partly destroyed by ulceration. A number of minute fragments from the fractured lumbar vertebra were driven into the adjacent soft parts. On sawing through the vertebræ from behind, a little to the right of the median line (Fig. 868), it was found that the spinal canal was not involved by the track of the missile. The spinal cord and other contents of the spinal canal presented no abnormal

¹ Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 446.

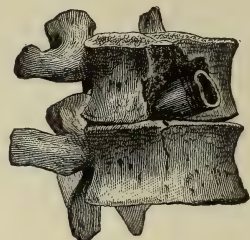
appearance. The fractured spongy tissue of the vertebræ was suppurating. The missile was lodged behind the pancreas. Secondary hemorrhage from the splenic artery had supervened, causing death seventy-eight days after the infliction of the wound.¹

Fig. 868.



Interior view of the last dorsal and first two lumbar vertebræ, in the case of President Garfield. They have been laid open from behind by sawing vertically through their laminae and bodies, a little to the right of their spinous processes. The intervertebral substances have been destroyed by the inflammatory process. The cancellated tissue of the bodies is extensively disorganized by suppurative osteomyelitis, as well as by the impact of the missile. $\frac{3}{4}$.

Fig. 869.



Showing two lumbar vertebræ that were perforated from behind forward, and were fissured vertically, through their bodies, by a conoidal musket-ball which passed into the peritoneal cavity. (Spec. 3583, Sect. I, A. M. M.)

In the case of President Garfield, the shot fractures of the last dorsal and first two lumbar vertebræ were followed by suppurative osteo-myelitis and destruction by ulceration of the corresponding intervertebral disks, from which disorders arose the symptoms of septicaemia that presented themselves at one time in the history of his case, and, finally, the secondary hemorrhage that destroyed his life. The prognosis in cases of suppurative osteo-myelitis arising from vertebral fractures is always very bad; in fact, such cases are scarcely amenable to any treatment.

In the following example, a conoidal musket-ball penetrated the lumbar portion of the spinal column from behind, passed forward through the bodies of the vertebræ, having crushed the spinal cord, and entered the abdominal cavity, where it wounded the liver, and likewise caused peritonitis, which proved fatal in four days:—

A corporal, having been wounded in front of Petersburg, on July 30, 1864, was sent to Washington, and admitted to Douglas Hospital, on August 3, with complete paraplegia and peritonitis. He died on the same day. *Necroscopy* revealed the passage of the missile into the abdominal cavity through the spinal column, and laceration of the liver, with peritoneal inflammation and the products thereof. The fractured vertebræ and the missile are represented in the adjoining wood-cut (Fig. 869).²

Small-arm missiles, as, for instance, musket and pistol balls, etc., often lodge in the bodies or apophyses of the vertebræ, in such a manner that either their position cannot be exactly ascertained, or they cannot be extracted in consequence of the firmness of their impaction. This important class of spinal injuries will be illustrated in a useful manner by the next half dozen abstracts and wood-cuts:—

A soldier, aged 20, was wounded in the back at Monocacy, Md., July 9, 1864, and admitted to hospital at Frederick, on the next day. The missile (a conoidal musket-ball)

¹ American Journal of the Medical Sciences, October, 1881, pp. 586-590.

² Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 444.

had entered at the inferior border of the left scapula, passed inward and backward, struck the spinal column, and lodged, having instantaneously caused complete paraplegia below the wound, with inability to micturate. On the 12th, the urine began to dribble away spontaneously, and defecation occurred involuntarily. He made no complaint of pain. Bed-sores over the sacrum, etc., depending upon the mal-nutrition of the parts which resulted from the injury of the spinal cord, soon followed. Nevertheless, he survived until October 13, and then died of pleuro-pneumonia. *Necroscopy* showed that the missile had passed through the left intervertebral foramen between the ninth and tenth dorsal vertebræ, producing only a very slight fracture; and, turning upward in the spinal canal, had lodged in it opposite the body of the fifth dorsal vertebra. The upper end of the spinal cord was much softened. The lodgment of the missile is well shown in the adjoining wood-cut (Fig. 870).¹

A soldier, aged 26, was wounded at Cold Harbor, Va., June 3, 1864, by a conoidal musket-ball, which penetrated the right side of his back, shattered the right transverse and articular processes of the eighth and ninth dorsal vertebræ, and entered the spinal canal. He immediately lost all sensation and voluntary motion below the wound. On the 11th, he was admitted to general hospital. There was then psychological depression, with slow pulse, labored respiration, cold, clammy, and cyanosed skin, and involuntary passage of the excretions. Gastric irritability supervened, with rejection of all kinds of nourishment, and he died on July 2. *Necroscopy* revealed the missile imbedded in the spinal canal, as shown in Fig. 871. The spinal cord was severed and disorganized above and below the missile.²

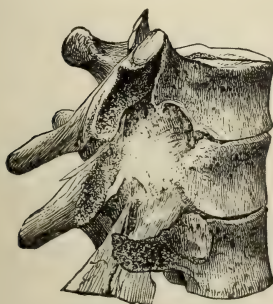
Corporal G. W. M., aged 19, was wounded at Cold Harbor, Va., June 3, 1864, and admitted to general hospital on the 7th. He was suffering from paraplegia with reten-

Fig. 870.



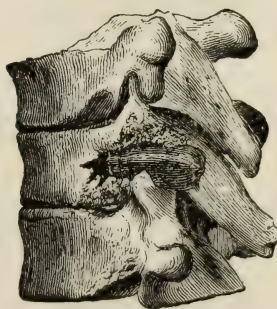
Showing the fifth, sixth, seventh, and eighth dorsal vertebræ, with the body, etc., of the fifth horizontally divided, and a conoidal musket-ball (also divided) lodged in the spinal canal. (Spec. 3984, Sect. I, A. M. M.)

Fig. 871.



Showing a conoidal musket-ball lodged in the spinal canal between the eighth and ninth dorsal vertebræ. (Spec. 2939, Sect. I, A. M. M.)

Fig. 872.



Showing gunshot fracture of the left transverse process and body of the seventh dorsal vertebra, with the missile *in situ*. (Spec. 3030, Sect. I, A. M. M.)

tion of urine and traumatic pneumonia. A conoidal musket-ball had entered his back near the inferior angle of the left scapula, and passing downward, inward, and forward through the left lung, had fractured the transverse process of the seventh dorsal vertebra, and lodged in the body of the same. Owing to his extreme prostration, no anti-

¹ Medical and Surgical History of the War of the Rebellion, First Surgical Vol., p. 440.

² *Ibid.*, p. 439

phlogistic measures of an active character were employed. Stimulating frictions were frequently applied to the legs and hips, and the chest was enveloped in an oil-skin jacket. He died on the 19th. *Necroscopy*.—The ball was found imbedded in the body of the seventh dorsal vertebra, encroaching upon the medulla spinalis, as represented in the accompanying wood-cut (Fig. 872). The lungs were hepatized at their bases; and, near their apices, were filled with a dark, frothy liquid.¹

A colored soldier, aged about 25, was wounded at Brownsville, Texas, January 28, 1866, by a pistol-shot, and died in thirty-eight hours, from shock and internal hemorrhage.

Fig. 873.

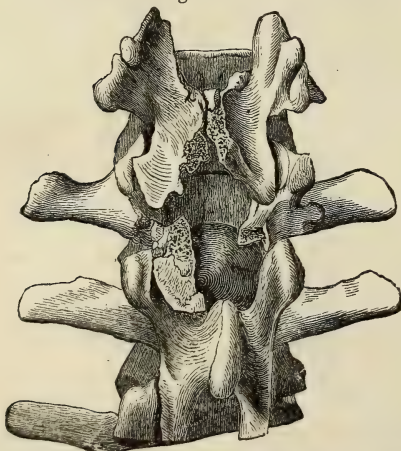


Showing a pistol-ball (calibre 37) lodged in the body of the last dorsal vertebra, having fractured the same with much comminution. (Spec. 3780, Sect. 1, A. M. M.)

Necroscopy showed that the missile had entered two inches below and outside of the left nipple, gouged its calibre from the upper border of the eighth rib, passed downward, inward, and backward, through the lower lobe of the right lung, the diaphragm, and the right lobe of the liver, and had lodged in the body of the last dorsal vertebra, fracturing it as shown in the adjoining wood-cut (Fig. 873), which represents the specimen now preserved in the Army Medical Museum.²

A quartermaster's sergeant, aged 36, was wounded at Compton, La., April 4, 1864, by a grape-shot, which entered his loins one inch to the right of the spinous processes, and about two inches below the

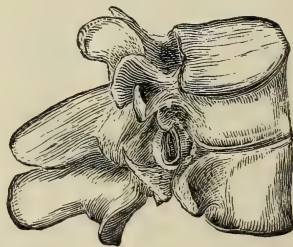
Fig. 874.



last rib, and, passing forward and slightly downward and inward, struck the spinal column, and, lodging, was not extracted. On the 10th he was admitted into University Hospital, at New Orleans. There was no paralysis. The symptoms of pyæmia, however, supervened, and he died of that disease on the 18th. *Necroscopy* revealed a round iron ball, about one inch in diameter, lodged on the left psoas magnus muscle. The spinous processes and laminae of the last dorsal and first lumbar vertebrae were fractured and displaced, and thus the spinal canal was laid open. The specimen is represented by the accompanying wood-cut (Fig. 874). Purulent infiltration was found in the psoas muscles, with their investments, and in the peritoneal cavity. Two small circumscribed metastatic abscesses were found in the right lobe of the liver. There were no signs of paralysis present during life.³

A sergeant of infantry was wounded at Opequon Creek, near Winchester, Va., Sep-

Fig. 875.



Showing a conoidal musket-ball imbedded in the intervertebral substance between the third and fourth lumbar vertebrae. (Spec. 3796, Sect. I, A. M. M.)

tember 19, 1864, by a conoidal musket-ball, which penetrated the lumbar region through the erector-spinae muscles, a few inches above the posterior crest of the ilium, and lodged.

¹ Med. and Surg. History of the War of the Rebellion, First Surgical Vol., p. 438.

² Ibid., p. 441.

³ Ibid., p. 443.

The left ankle and lower third of the femur were shattered, for which amputation of the thigh was performed. The only symptom, indicating that the spinal cord or spinal nerves were injured, was paralysis of the right leg. *Necroscopy.*—The missile was found imbedded in the intervertebral substance between the third and fourth lumbar vertebræ, as shown in the adjacent wood-cut (Fig. 875), which represents the specimen. There was very little pus in the wound.¹

Prognosis.—Gunshot lesions of the spinal column are very serious injuries. They proved fatal in more than one-half of the instances which came under treatment during our late civil war; and many who sustained such injuries must have perished on the field before any treatment could be adopted.

Six hundred and forty-two cases of gunshot injury of the vertebræ were reported by our military surgeons during the late civil war. Of these, three hundred and forty-nine, or 55.5 per cent., proved fatal; one hundred and seventy-five soldiers were discharged from the service; one hundred and four were returned to duty; while, in fourteen instances, the result is not known. Again, of these six hundred and forty-two cases, the cervical vertebræ were injured in ninety-one, with a mortality of sixty-three, or 70 per cent.; the dorsal vertebræ, in one hundred and thirty-seven, with a mortality of eighty-seven, or 63.5 per cent.; the lumbar vertebræ, in one hundred and forty-nine, with a mortality of sixty-six, or 45.5 per cent.; the cervical and dorsal, in two instances, of which one proved fatal; and the dorsal and lumbar, in three instances, which all proved fatal. In two hundred and sixty cases, where the injured vertebræ were not specified, one hundred and twenty-nine, or 49.4 per cent., proved fatal.

The percentage of mortality above stated is, for vertebral injuries in the cervical region, 70, for those in the dorsal region, 63.5, and for those in the lumbar region, 45.5. Other things being equal, the prognosis is less unfavorable in cases where the dorsal vertebræ are wounded by gunshot missiles, than it is in cases where the cervical vertebræ are injured in this manner; and, in cases where the lumbar vertebræ are affected, it is much less unfavorable than it is in cases where the dorsal vertebræ are involved, and very much less unfavorable than it is in cases where the cervical vertebræ are injured.

Gunshot fractures of the cervical vertebræ, when attended by complete paraplegia, are almost always fatal; and, generally, death occurs before the fourth day in such cases. I had under my care at the battle of Fair Oaks, May 31 and June 1, 1862, two cases in which there were fractures of the lower cervical vertebræ caused by musket-balls.

In both cases, the upper as well as the lower extremities, and all the parts and organs that were supplied with spinal nerves which issued from the spinal column at or below the seat of the lesions, were completely paralyzed in respect to both sensation and voluntary motion. There was retention of urine and feces, and catheterization had to be resorted to. The respiration was entirely diaphragmatic, for all the respiratory nerves, excepting the phrenic, were paralyzed. The inferior margin of the thorax was also drawn inward, whenever the diaphragm contracted, thus reducing the antero-posterior and lateral diameters of the chest, as well as increasing the vertical diameter thereof, at the end of every movement of inspiration. The muscular wall of the abdomen was relaxed and flaccid till tympanites supervened, which added much to the respiratory embarrassment. Both patients died asphyxiated; one of them on the third, and the other on the fourth day after the injury was inflicted. The intellect was clear in both cases, and there were no head-symptoms whatever, until the stupor of asphyxia approaching a fatal termination appeared. No autopsies were held, from want of time to make them.

¹ *Ibid.*, p. 450.

A. M. Soteldo was wounded, on Thursday night, February 9, 1882, at the editorial rooms of a Washington newspaper, by a cylindro-conoidal pistol-ball, which entered the back of his neck four inches below the occipital protuberance and slightly to the left of the median line, passed forward and slightly upward, fractured the lamina of the fourth cervical vertebra a little to the left of the spinous process thereof, penetrated the spinal dura mater (theca vertebralis), and imbedded itself in the left intervertebral foramen between the fourth and fifth cervical vertebræ, having bruised and slightly lacerated the spinal cord, and driven into its substance a small splinter of bone. He immediately became "paralyzed from the head down," that is, all of his extremities and the whole of his body below the neck, were completely deprived of sensibility and voluntary motility. The respiratory movements were performed by the diaphragm alone. He died at 10 h. 25 m. on the night of Saturday, the 11th, about forty-eight hours after the casualty occurred. The *autopsy* revealed the course and place of lodgment of the missile, and the injuries done by it, which have just been described. The missile weighed, after extraction, eighty-seven grains.

There is, however, recorded in the first surgical volume of the Medical and Surgical History of the late Civil War, at page 430, a case of gunshot fracture of the body of the third cervical vertebra, with lodgment of the missile and complete paraplegia, in which recovery was secured by persevering treatment. A brief abstract of this case should be presented in this place, because it will encourage surgeons to give more attentive treatment to such cases, by showing that they are not always hopeless:—

An infantry soldier, aged 20, was wounded at Gettysburg, July 2, 1863, by a conoidal ball, which entered the right upper lip at the second incisor, destroyed all the teeth save the last molar, on the same side of the upper jaw, passed below the soft palate into the pharynx, and penetrated the body of the third cervical vertebra, where it lodged and was not extracted. But in the following August, the position of the ball was ascertained by a Nélaton's probe, and it was then extracted. "There was paralysis in all four limbs, from which, however, he rapidly recovered; and, for a time, did duty as hospital attendant." On March 14, 1864, this patient was transferred to Turner's Lane Hospital, at Philadelphia. Acting Assistant-Surgeon W. W. Keen, Jr., on duty at that hospital, states that "nearly the entire body of the third cervical vertebra has come away, including the anterior half of the transverse process and the vertebral foramen. No injury to the vertebral artery has been disclosed. What supports his head anteriorly I cannot conceive. On May 3, he was transferred to Washington to be assigned to a company in the Veteran Reserve Corps. The only remnant of his paralysis is some [loss] of sensation over a surface, say three by four inches, at the back of right neck. Some bone still is occasionally discharged." In April, 1871, this man was yet alive; and the pension-examiner reports that the right side of his tongue is distorted, leaving his speech affected; that the right side of his throat is contracted; and that his right shoulder and arm are diminished in size and partially paralyzed. Disability three-fourths and permanent.

But gunshot fractures of the spinal column, and particularly those in the cervical and upper dorsal regions thereof, are generally mortal, unless the lesions be confined to their apophyses.¹ In the Schleswig-Holstein campaign of 1849, Stromeyer observed that "injuries of the spinous processes frequently occurred without serious consequences—without accidents from concussion of the spinal marrow."² During the late civil war I saw a considerable number of cases in which the spinous processes alone had been broken off by the im-

¹ In the British army, during the Crimean war, "all the fractures of the vertebræ were promptly fatal, except two among the officers and two among the men, all of which were either fractures of the transverse processes in the neck, or of the spinous processes only." (Medical and Surgical History of the British Army in the War in the Crimea, etc., vol. ii. p. 337.) Thus it appears that the only cases of shot fractures of the vertebræ which terminated in recovery among the British soldiers and officers wounded in the Crimean war, were those in which the lesions were restricted to the spinous and transverse processes.

² Op. cit., p. 37.

pect of small-arm missiles, without any apparent fissuring of the laminae or bodies, etc., of the injured vertebræ, and without any serious lesion of the spinal cord. These patients all recovered.¹ In some of these cases, spinal paralysis, too, was present at the outset, but it probably arose from concussion of the spinal cord, for it soon passed away. Professor Ashhurst² mentions, in point, the case of a soldier, seen by himself, who was wounded by a musket-ball in the lumbar region. The missile entered to the left side of the spinal column, carried away the spinous process of a lumbar vertebra, and lodged; it was extracted from the right hip many months afterward. At first there was spinal paralysis. This soldier recovered and was transferred to the Veteran Reserve Corps. Nearly two years subsequent to the casualty his back was yet stiff, and occasionally painful. Most of the 104 patients having gunshot lesions of the spinal column, who recovered and were returned to duty in our army during the late civil war, doubtless sustained merely fractures of the spinous or transverse processes. Indeed, the abstracts of the successful cases belonging to this category, which are presented in the surgical history of the war, strongly support this view. It is, therefore, but reasonable to conclude, that in cases of gunshot fracture of the vertebræ, the prognosis is very much less unfavorable when the lesion is restricted to the spinous or transverse processes, than when other parts are involved.

A few, however, of the one hundred and four patients having gunshot fractures of the vertebræ got more or less completely well again, when the bodies, or the laminae, or the vertebral pedicles were broken, and when the spinal cord was at the same time considerably injured. For, "in fifty-four cases of gunshot injury of the vertebræ, complicated by traumatic lesions of the cord, forty-two were fatal, and twelve partially recovered and were discharged, with various degrees of physical disability. The cases of contusion and commotion of the spinal cord are not included in this category."³ Some, at least, of those who were returned to duty must have been affected with contusion and commotion of the spinal cord, and with lesions of the vertebræ more severe than fractures restricted to their apophyses.

Professor Paul F. Eve⁴ reports two cases of gunshot injury of the spinal column, which the victims long survived, and in which the missiles remained lodged in the spine. Again, Surgeon C. S. Tripler, U. S. Army,⁵ relates the case of an officer who, in 1839, during the last Seminole campaign in Florida, was wounded in the loins by a rifle-ball, which penetrated on the right side, in a line with the junction of the last dorsal and first lumbar vertebræ, struck the spinal column, lodged, and was not extracted. There were complete paraplegia and priapism, with retention of urine and feces. He survived for twelve years. The paralysis, however, but slightly improved. The catheter, and laxatives or enemata, had to be used for about two years, that is, until, in 1841, he found that he could stimulate the bladder and rectum to contract by tickling the side of his penis behind the corona glandis.⁶ M. Hutin, of the French Army,⁷ mentions the case of a soldier, aged 20, who, in 1835, was wounded in the loins, in Algeria. The ball entered on the right side, near the first and second lumbar vertebræ, and, lodging therein, was not extracted. There was immediate paraplegia. In three months the wound healed. This soldier survived the injury fourteen years, and died of Bright's disease. An *autopsy* revealed the ball lodged in the spinal canal; it had severed the right half of the cauda equina and displaced the left half; medullary substance much

¹ Am. Journ. of the Med. Sciences, October, 1864, p. 315.

² Op. cit., pp. 116, 117.

³ Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 453.

⁴ American Journal of the Medical Sciences, July, 1868, pp. 103-107.

⁵ New York Journal of Medicine, 1851.

⁶ A case of shot fracture of the seventh dorsal vertebra, with paraplegia, is mentioned on p. 438, of the First Surgical Volume of the Med. and Surg. History of the War of the Rebellion, in which tickling of the glans penis likewise produced urination, and partial evacuation of the bladder, by exciting the detrusor urinæ muscle to contract. (See page 407, *infra*.)

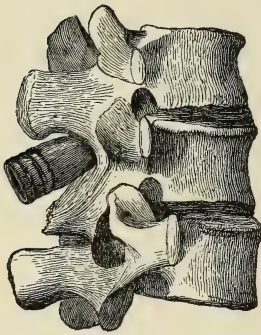
⁷ Lancet, 1849.

disorganized. M. Louis, the most celebrated French surgeon of the eighteenth century,¹ relates the case of a soldier who, in 1762, received a gunshot wound of the dorsal spine, in consequence of which he became completely paralyzed in the lower limbs; the wound was enlarged at once, and the ball taken out. Louis saw the patient on the fifth day after the casualty; he found that there were several fragments of bone pressing upon the spinal cord. He removed these fragments; and, although there was a considerable suppuration after this operation, the paraplegia slowly but gradually disappeared, and the patient was completely cured, excepting a slight weakness which remained in his lower limbs. Twelve years afterward, however, he still had to walk with a cane. These facts and examples are mentioned mainly with a view to encourage surgeons to conduct in a thorough manner the treatment of gunshot fractures of the spinal column, in all instances which come under their care, by showing that, even in cases where recovery is impossible, life may be greatly prolonged by careful treatment.

The prognosis of these cases is rendered much more unfavorable by the occurrence of inflammation of the spinal membranes or spinal cord, as doubtless happened in the following instance:—

A soldier, aged 19, was admitted to Emory Hospital, Washington, August 25, 1862, for a gunshot wound of the back, received on the night of the 22d. He was then in

Fig. 876.



Showing gunshot fracture of the spinous process of the second lumbar vertebra, with the missile impacted between the laminae of the first and second. (Spec. 611, Sect. I, A. M. M.)

A. M., when he died. *Necroscopy*.—The ball was found to have destroyed the spinous process of the second lumbar vertebra, and to have buried itself, apex foremost, between the laminae of the first and second, in the spinal canal, bruising and pressing upon the spinal cord.²

The condition of the spinal membranes does not appear to have been noted at the autopsy. Nevertheless, the symptoms which characterized this case, *e. g.*, the intense rachialgia, the extreme degree of restlessness, and the tetanic spasms, are symptoms which often present themselves in cases of idiopathic, as well as in cases of epidemic, spinal meningitis; and, no doubt, there was traumatic spinal meningitis of an acute character in this case. The patient survived the onset of the acute symptoms, less than two days. It also appears that chloroform was administered continuously for several hours before death occurred. Was the proximate cause of death the disease, or the chlo-

¹ Mémoire posthume. Archives Gén. de Médecine, etc., Août, 1836, p. 397; Brown-Séquard's Lectures on the Central Nervous System, p. 251.

² Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 444.

roform which was administered in order to relieve the symptoms? In six additional cases of gunshot injury of the vertebral column, during the late civil war, analogous symptoms were reported; and it appears that these cases were all fatal.

Another bad prognostic in gunshot injuries of the spinal column is the occurrence of *bed-sores*, especially when they arise from the trophic disorder of the tissues which results from lesions of the spinal cord.

A still more evil portent in such cases is the appearance of *metastatic abscesses*, especially when they spring from the septicæmia that results from suppurative inflammation of the cancellated tissue (osteomyelitis) of the fractured vertebræ. A considerable number of instances of this sort were reported during the late civil war; and metastatic abscesses arising from this cause were more recently observed in the case of President Garfield, already mentioned above, where it is stated that the fractured spongy tissue of the injured vertebræ was suppurating, and that the adjoining intervertebral cartilages were partly destroyed by ulceration.

Diagnosis.—The presence of an open wound that has been made by a gunshot missile, the track of which extends in a direct line to the vertebral column, the impairment of function evinced by the stricken portion of the vertebral column, and the exploration of the wound with a finger, whenever practicable, by which the fragments of the broken vertebræ themselves can be felt, usually suffice to establish the diagnosis in a satisfactory manner.¹

Treatment.—If the missile has lodged, it should be found and extracted, if possible. All foreign bodies, *e. g.*, bits of clothing and of accoutrements, blood-clots, and detached or quite loosened splinters or fragments of bone, should likewise be extracted. The utmost cleanliness should be observed, antiseptic dressings should be applied, drainage-tubes should be used to prevent any collections of matter from being formed in the wounds, and necrosed fragments of bone should be removed as soon as they become detached. Fragments of the vertebræ were extracted, after gunshot fractures thereof, in twenty-four instances during the late civil war. Of these cases only ten were fatal.² In all of the fourteen cases which did not prove fatal, there was recovery more or less complete. In seven of the nine instances in which the spinous process alone, or portions of it only, were extracted, the patients recovered speedily as well as completely, and were returned to duty, or exchanged. In one instance belonging to this category, which was under my care for two and a half months at Stanton Hospital, there was paraplegia from concussion of the spinal cord, as well as gunshot fracture of the spinous process of the second lumbar vertebra. Several fragments which became detached were promptly removed, and the paralysis, all things considered, rapidly passed away.³ This man's recovery was complete, for "his name is not on the pension-list, nor have his heirs made application for pension."⁴ But, in five successful cases wherein portions of the laminae or of the transverse processes were removed, the results were much less satisfactory; nearly all of these patients were still suffering from serious disabilities in 1872.⁵

¹ There is, however, on record the case of an officer, in which a pistol-ball, after fracturing the right humerus, passed into the chest, and, lodging, was not extracted; fifteen days afterwards, he died of pneumonia and secondary hemorrhage. *Necroscopy* showed the missile firmly imbedded in the body of the fifth dorsal vertebra, nearly the whole of which was shattered. Nevertheless, no spinal symptoms had been developed, and the lesion itself had not been suspected during life. The specimen is preserved in our Army Medical Museum (No. 3515, Sect. I). (Medical and Surgical History of the War of the Rebellion, First Surgical Vol., p. 436.)

² Medical and Surgical History of the War of the Rebellion, First Surgical Vol., p. 459.

³ American Journal of the Medical Sciences, October, 1864, p. 327.

⁴ Medical and Surgical History of the War of the Rebellion, First Surgical Vol., p. 459.

⁵ Ibid.

Again, in order to prevent the occurrence of inflammatory lesions in the spinal membranes and spinal cord, absolute quietude should be enjoined on the patient. Catheterization, and laxatives, or enemata, as well as the precautions against bed-sores and vesical and renal inflammation which have already been mentioned, should be promptly employed whenever their use is indicated. Whatever complications may arise, *e. g.*, osteo-myelitis of the fractured vertebræ, spinal meningitis, spinal myelitis, septicæmia, bed-sores, nephritis, cystitis, etc., should be promptly met by appropriate treatment.

ON TREPHINING (SO CALLED), OR RESECTION OF THE SPINAL COLUMN.

The operation of excising parts of the vertebræ with a trephine, a saw, a bone-forceps, or a chisel and mallet, and removing the same, when they are fractured and displaced so as to cause paralysis by compressing the spinal cord, has been suggested by many surgical writers, the earliest of whom was Paulus Ægineta. It was first performed, however, by Henry Cline, at St. Thomas's Hospital, June 16, 1814, in the case of a man, aged 26, who, by falling from a second-story window, on the previous day, had received an injury of the dorsal vertebræ, with considerable displacement, and had become paraplegic.

The man having been put upon the operating table with his face downward, an incision was made through the skin over the projecting spinous processes, of sufficient length to expose them completely. The muscles were then divided on each side, and, being drawn outward, two spinous processes, which were broken at their roots, were removed. It was attempted (but ineffectually) to remove the eleventh vertebral arch by sawing it through with Machell's circular saw; a chisel and mallet were then employed, and also a trephine, by means of which the separation was effected, and the arch lifted out with an elevator. The operation was considerably embarrassed by the unfitness of the instruments, and occupied considerable time, but afforded no relief. In the evening he complained of pain in the wound; pulse 114. June 17, 2 P. M. Had not slept since the operation; pulse 130. At 6 P. M. he had a fit, and was thought to be dying. June 18, 1 P. M. Had another fit; had great difficulty of breathing, with much restlessness; pulse 140; upper part of body in a cold sweat, lower part warm, but not perspiring. At 4 P. M. the spasms had abated. June 19. He was more tranquil, but gradually sank, and died at 5 P. M. without convulsions, and sensible to the last. *Autopsy.*—The fore and upper part of the body of the twelfth dorsal vertebra was fractured obliquely from above and behind, downward and forward. The upper fragment remained attached by the intervertebral substance to the body of the eleventh dorsal, which had moved forward and a little downward, tearing off the posterior half of the intervertebral cartilage from the top of the twelfth dorsal vertebra. The theca vertebralis was lacerated, opposite the seat of injury, in four places, two of which would admit the little finger. The spinal cord was three-fourths torn through, and the remaining portion was bruised.¹

Mr. Cline himself candidly stated that he thought the operation had hastened the death of his patient. The lesions for which he operated consisted of fracture of the body of the twelfth dorsal vertebra with displacement (partial dislocation) of the body of the eleventh (to which the fragment of the twelfth still adhered), forward and slightly downward, and extensive laceration of the spinal cord. He removed two spinous processes, and the laminae of the twelfth dorsal vertebra. The foregoing abstract shows the true character of this operation, the difficulties which attend its performance, and its positive harmfulness as well as its inutility, more clearly and in fewer

¹ South's Notes to Chelius's Surgery, vol. i. pp. 590, 591, Am. ed.

words, than any disquisition on the subject could do. Moreover, this operation has been repeated many times, without success. Professor Ashhurst has collected and tabulated 41 cases in which it has been performed. Of the whole number of patients, 30 died, 3 were relieved, and 3 received no benefit, while of 5 cases the result is unknown. There is no example of a cure achieved by it on record. Surely the general results in these cases would have been much better if the operation had not been performed. It is not improbable that even the few who were apparently relieved by it would have done better without it. The operation of resection or trephining the vertebræ is unjustifiable, because it does not offer a reasonable prospect of improving the patient's condition in any case, while, on the other hand, there is always reason to fear that it may increase the chances of a fatal termination.

M. Louis's operation, which was performed in 1762, is sometimes referred to as the first instance in which the spinal column was resected, but it was not a resection at all. It consisted merely in extracting some loose fragments of bone, on the fifth day, in a case of gunshot fracture involving a dorsal vertebra. The patient improved, but, twelve years later, still had to walk with a cane, as has already been stated above. Moreover, the same operation was performed in twenty-four instances during our civil war, and with quite satisfactory results. But resection of the vertebræ is not admissible in gunshot injuries of the spine. Mr. Guthrie¹ mentions a patient who had received a pistol-shot which lodged in the last dorsal or upper lumbar vertebra, and caused complete paralysis of both limbs, and who searched London and Paris, in vain, to find a surgeon willing to operate on him. Professor Paul F. Eve, of Nashville, Tenn., however, once did attempt to perform such an operation,² in the case of a Confederate soldier, who had been wounded by a pistol-ball that entered to the left of the spinal column, about one inch from the spinous process of the sixth dorsal vertebra, in the cavity of which, or of the seventh, it was supposed to be lodged. Paraplegia immediately ensued, and the paralysis proved to be permanent. Concerning the operation of resecting the dorsal vertebræ, which was attempted, Prof. Eve says: "After due preparation, a free incision was made through the cicatrix, and an attempt made to follow this into the vertebral cavity; but so deep was the vertebral groove down to the transverse processes, so indistinct the track of the missile—indeed, we could not trace it—so deceptive the intervertebral foramina, etc., but, above all, so great the risk of exciting inflammation by wounding the sheath of the spinal cord, that we concluded, after using one crown of the trephine, of medium size, over what all believed to be the hole made by the bullet, to desist from further application of it. I am satisfied," he continues, "that this operation, in the dorsal vertebræ, if not almost impracticable, is certainly one of the most difficult in surgery."

That the operation of trephining the spinal column or resecting the vertebræ will not relieve the spinal cord from compression, when it is exerted by the extravasation of blood, is proved by the case of a derrick-man, aged 41, in whom the laminae of the tenth dorsal vertebra were resected, at Bellevue Hospital, by Dr. Stephen Smith; for, notwithstanding that from 8 to 12 ounces of extravasated blood, having a dark color, escaped from the spinal canal after the depressed bone had been extracted, the compression of the cord from extravasated blood, and the paraplegia, steadily crept upward, and finally caused death by asphyxia.³

¹ Commentaries, etc., p. 541, Am. ed.

² American Journal of the Medical Sciences, July, 1868, p. 106.

³ New York Journal of Medicine, 1859, pp. 87, 88.

III. INJURIES OF THE SPINAL MEMBRANES, SPINAL CORD, AND SPINAL NERVES.

INJURIES OF THE THECA VERTEBRALIS, AND MENINGES OF THE SPINAL CORD.

The spinal dura mater, although but loosely connected with the bodies of the vertebræ, is elsewhere strongly attached to the vertebral walls, at frequent intervals, by means of processes sent out through the intervertebral foramina around the spinal nerves. Consequently, when the vertebræ are fractured, or displaced in luxations, the spinal dura mater is extremely liable to be stretched, bruised, or torn. I assisted, on one occasion, at the autopsy in a case in which there were fissured fractures of the fifth, sixth, and seventh cervical vertebræ; there was little displacement, yet the theca vertebralis was found smeared with blood opposite the fractures, and torn open so widely as to allow the index-finger to pass through with ease. (See page 301.) So too, in Mr. Cline's case, which has just been related, the theca vertebralis, at the autopsy, was found lacerated in four places, two of which would admit the little finger. But to multiply examples of this sort would be useless; for it is quite obvious that, in all fractures of the vertebral rings with displacement, whether the fragments spring back into place again or not, and in all luxations of the vertebræ, the theca vertebralis must be correspondingly injured by the stretching, bruising, or tearing which it of necessity sustains from the sudden displacement, or from the sharp edges and splinters of the broken or dislocated bones.

But aside from strains, bruises, and lacerations, the theca vertebralis may be penetrated by *incised and punctured wounds* of the back. Many instances are on record in which such wounds of the theca vertebralis were made by knives, daggers, swords, lances, arrows, and bayonets, and with such implements of industry as chisels, etc. Several examples have already been mentioned in this article. (See page 270.) When such wounds are attended by a discharge of cerebro-spinal fluid, there is no doubt that the theca vertebralis has been opened. When the wound is situated in the loins, and the discharge of the cerebro-spinal fluid is profuse, the nature of the lesion may be mistaken, and it may be supposed that the ureter has been laid open. There is published in the sixtieth volume of the *Medico-Chirurgical Transactions*, a case in which a copious flow of limpid fluid occurred from a wound in the back, and in which it was believed that the ureter had been laid open, although it was admitted to be possible that the fluid might be cerebro-spinal. Mr. T. Holmes¹ relates two cases in which a similar copious discharge of watery fluid was caused by a wound of the spinal membranes, which did not involve the spinal cord nor the large nerves, as was proved by the post-mortem examination in one case, and by the position of the puncture in the other. Incised or punctured wounds of the back, which open the theca vertebralis without injuring the spinal cord or spinal nerves, do not, of themselves, produce any nervous phenomena, inasmuch as the loss of the cerebro-spinal fluid is usually but gradual, and the fluid itself is rapidly resecreted. Secondary inflammation of such wounds, however, may interfere with the functions of the spinal cord or spinal nerves, and may even destroy life in that way. But when such wounds are uncomplicated, the prognosis is generally favorable. There may, however, be great difficulty in getting permanent closure of the wound in such cases; but there will be more chance of getting it if treat-

¹ *Lancet*, April 29, 1882; *American Journal of the Medical Sciences*, July, 1882, p. 294.

ment to that end be employed at once, than if it be postponed to a later period.

Gunshot wounds of the spinal dura mater not unfrequently occur. In cases where they are present, the vertebræ are always fractured, and the spinal cord, likewise, is generally injured. Many examples have been presented in the foregoing pages in which the theca vertebralis was torn by gunshot missiles. Sometimes, as in the case of Soteldo (p. 374), the bullet penetrates the theca and lodges therein. In others, it perforates that membrane, and leaves behind an orifice of emergence as well as of entrance. In others still, it tears a furrow transversely across the tube which the theca vertebralis forms when *in situ*, and partially divides the same. The amount of thecal inflammation aroused by gunshot injuries is in most instances, I think, not great. At an autopsy which I made some years ago, in a case in which the last-named form of injury was found, I was rather surprised at the absence of inflammation, although the patient had survived the casualty twelve days, and I made the following note at the time concerning it: "There was moderate inflammatory action, adhesive in character, of the theca vertebralis. It was confined to the immediate neighborhood of the wound. There was no pus." It is my belief that the spinal dura mater is normally endowed with a wonderful ability to resist traumatic lesions and their consequences. But injuries of the spinal arachnoid and pia mater not unfrequently cause inflammations of a destructive character therein, which will be discussed under the head of Traumatic Spinal Meningitis.

Moreover, suppurative inflammation of the connective tissue, and abscess, may occur between the spinal dura mater and the vertebral column, in consequence of the injury thereof, especially when the latter has sustained a simple fracture without displacement; two examples of this have already been presented under the caption of *latent fractures* of the vertebræ. (See p. 349.)

Injuries of the spinal meninges are often attended by extravasation of blood within the theca vertebralis, and compression of the spinal cord resulting therefrom. Many instances have been mentioned in the foregoing pages, and eight additional examples will be presented in the next section of this article.

Treatment.—Incised and punctured wounds of the back, which penetrate the theca vertebralis and let out the cerebro-spinal fluid, should be treated by immediate closure and antiseptic dressings for the wounds themselves, and by absolute quietude for the patients.

Gunshot wounds involving the theca vertebralis require for treatment the removal of all foreign bodies, such as blood-clots and loose fragments of bone, as well as bullets and bits of clothing, the employment of antiseptic dressings, with drainage-tubes, and perfect rest for the injured spine.

Simple fractures or dislocations of the vertebræ, which do injury to the theca vertebralis, should first be "set" or reduced if possible, and then inflammatory action in the injured parts should be restrained by abstracting blood with leeches or cups, by applying cold, and by securing perfect rest for the injured structures.

INJURIES OF THE SPINAL CORD AND SPINAL NERVES.

The histological elements of the spinal cord, its nerve-fibres, ganglion-cells, minute bloodvessels, and connective tissue, are so lacking in strength and solidity that, were the cord as a whole not protected from the effects of external violence by an elastic medium, the cerebro-spinal fluid, which everywhere surrounds it, the elementary structures that compose it would be disintegrated

by every sudden shock, as well as by every sudden pressure and the impact of every vulnerating body, which might be brought to bear upon it.

The traumatic lesions to which the spinal marrow is exposed are (1) *concussion*, (2) *contusion*, (3) *compression*, and (4) *wounds* (incised, punctured, and lacerated), which partially or completely sever it.

CONCUSSION OF THE SPINAL CORD.—As the symptoms of concussion of the brain result directly from cerebral “shock,” so the symptoms of concussion of the spinal marrow result directly from sudden “shock” of that organ; as concussion of the brain is nearly always attended by minute extravasations of blood, or ecchymoses, so probably concussion of the spinal marrow is usually accompanied by minute effusions of blood into its substance;¹ and as the symptoms of concussion of the brain consist of a more or less complete suspension of the cerebral functions, so the symptoms of concussion of the spinal marrow consist of a more or less complete spinal paralysis, which, however, is usually ephemeral in character.

But concussion of the spinal cord, when extremely severe, may instantaneously destroy life. For instance:—

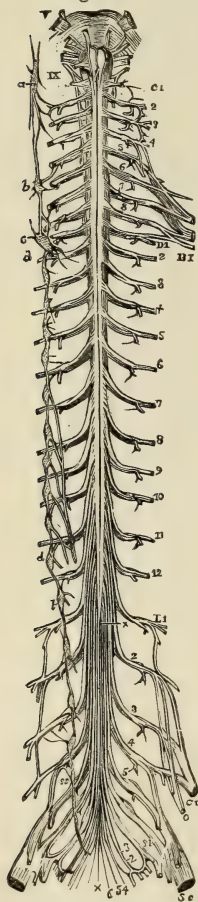
Major Mills, an officer serving on the staff of Major-General Humphreys, then commanding the Second Army Corps, was killed, March 31, 1865, during a reconnoissance, by a cannon-ball (round) which grazed his left lumbar region in such a way as to open the abdominal cavity and let out some intestine. General Humphreys says “he rolled up his eyes and fell from his horse dead.” Surgeon Charles Page, U. S. Army (Medical Director, 2d Corps), to whom I am indebted for the case, thinks he must have died from “shock,” for there was no solution in the continuity of any organ found on post-mortem inspection which would cause immediate death *per se*. While this view is doubtless correct, it is not improbable that the “shock” itself caused death by producing concussion of the spinal cord of so severe a kind, that all the respiratory muscles, including the diaphragm, were at once completely paralyzed thereby.

Again, death from this cause may ensue in a few hours. For example:—

Morgagni² relates the case of a man injured by falling from a vine. He was speechless and paralyzed, and bled from the nose and mouth. The urine and feces escaped involuntarily. Death ensued in four hours. *Necroscopy* revealed fractures of the six upper dorsal vertebræ, ribs, and skull. (Ashhurst.)

Ordinarily, in cases of vertebral fracture or dislocation attended with spinal paralysis, there is at first retention of urine and feces, because the sphincter muscles still remain active, while the muscular coats of the bladder and intestines are paralyzed. Not so in

Fig. 877.



Showing the spinal cord and the roots of the 31 pairs of spinal nerves, with the cervical, axillary, lumbar, and sacral plexuses. Also one of the two chains of vertebral ganglia (nervi sympathici), and the communicating threads.

¹ There is, however, a case of concussion of the spinal cord on record in which there was paraplegia that persisted (for three weeks) until death was produced by other causes, and, on *autopsy*, no lesion of the cord could be discerned. “No fracture of the vertebræ existed, nor were any appearances found in the spinal column sufficient to account for the persistent paraplegia.” Medical and Surgical History of the British Army in the Crimean War, vol. ii. pp. 337, 338.

² De Sedibus et Cæsis Morborum, t. iii.

this case, however, for the sphincter muscles, too, were paralyzed from the outset; and this circumstance shows that the nervous centres upon which their activity depends, together with the sympathetic ganglia—the *nervi sympathici*—suffered from concussion as well as the spinal cord.

Fractures of the spinal column are often attended by concussion of the spinal cord, much oftener, I fancy, than dislocations are.

Occasionally, concussion of the spinal cord is attended by a peculiarly violent shock to the *nervi sympathici*, as was noted in the following highly instructive example:—

Surgeon A. F. Mechem, U. S. Army, was injured by jumping from a railway train while in motion, June 21, 1870. The fall caused partial concussion of the spinal cord, and severe shock to the sympathetic nervous system. When seen, shortly afterward, slight reaction had come on; still, there was extreme hyperæsthesia of the chest, neck, and upper extremities, which were of a cyanotic hue; cerebral functions undisturbed. The heart's action, almost suspended when first seen, rose under stimulants. When reaction had fairly taken place, there was violent arterial action at the wrist, but unaccompanied by similar action in the temporal and carotid arteries; in fact, the action of these vessels coincided in neither force nor frequency with that of the radial and ulnar arteries. Nor was the action of the heart, at any time after the pulsations became normal, other than healthy, although the extraordinary throbbing at the wrist continued several days. Excepting slight paralysis of the bladder, there was no loss of motor power. At first, the terrible hyperæsthesia of the hands and arms caused a suspicion that there might be a fracture or a dislocation of the cervical vertebræ, which, by pressing upon the spinal nerves, produced the terrible pain. However, a careful examination showed that there was neither fracture nor dislocation, but that the cause of the symptoms was to be found only in the spinal cord and sympathetic nervous system. Morphia was administered hypodermically, and afforded much relief. Cupping, with hot applications of lead-water and laudanum, alternating with fomentations of hops and laudanum, to the arms, hands, and thorax, assisted materially in mitigating the pain. Some three days after the injury, the use of morphia was in a great measure dispensed with, Indian hemp and hyoscyamus being substituted. The hop-fomentations were superseded by applications of chloroform and camphor, alternated with morphia and simple cerate. Tonics, nourishing diet, and stimulants, contributed much toward recovery; but his health remained delicate. In January, 1871, he availed himself of a leave of absence for one month, which was extended six months longer, for the benefit of his health. He died July 14, 1871, in consequence of the accident; no autopsy reported.¹

Concussions of the spinal cord are often caused by gunshot injuries. I have reported three examples in the American Journal of the Medical Sciences,² in an article on Injuries of the Spine. In one of them the spinous process of the second lumbar vertebra was fractured. The symptoms were spinal paralysis (paraplegia), both motor and sensory; the former being more pronounced than the latter, which gradually subsided. Dry cups applied daily over the spinal column were found useful.

The abstract of another case, taken from my field note-book, will considerably aid in illustrating the symptoms of this accident:—

April 6, 1865, I examined a fine cavalry soldier, aged 19, at the field hospital near Jetersville, Va., who had been wounded at Amelia Court House, on the 5th, by a conoidal musket-ball, which passed through the back part of his lumbar region, obliquely from side to side, injuring the spine. He had paralysis, as to motion, of the parts below. The sensibility, too, was diminished, but not entirely destroyed. He complained of hyperæsthesia in the front and inner part of each thigh. He said that he had been hurt in these parts by the fall of his horse, and by being trampled upon, during the cavalry charge at Amelia C. H. on the 5th. He said that both lower extremities felt benumbed. His bladder was paralyzed, and catheterization indispensable. He also said that he did

¹ Circular No. 3, S. G. O., August 17, 1871, pp. 112, 113.

² No. for October, 1864, pp. 325–328.

not feel the catheter in the urethra until it reached the prostatic portion. He told this while the instrument was being introduced. Evacuation of the bladder afforded much relief from distress, for which he expressed his gratitude. Was the disorder in this case concussion of the spinal marrow? Yes; for the persistence of sensibility in both lower extremities, when the primary injury was caused by a minié ball, shows that the continuity of the spinal marrow was not seriously impaired. April 8. Saw this patient again at Burk's Junction; condition as to paralysis unchanged. April 11. Still no change; he was sent to-day to the depot field hospital at City Point, and thus passed out of my sight.

Professor Ashhurst¹ relates the case of a soldier, who had sustained a gunshot fracture of the spinous process of a lumbar vertebra, with concussion of the spinal cord. At first, there was spinal paralysis; but the man recovered and was transferred to the Veteran Reserve Corps.

Dr. George McClellan² mentions two cases, in which gunshot missiles entered the small of the back and lodged, where their impact caused concussion of the spinal cord and "total paraplegia of all the parts below." The paralysis, however, was but temporary; for both patients got perfectly well again under the use of laxatives and counter-irritants.

The *symptoms* vary greatly with the case, and according to the severity of the concussion itself, from simple motor enfeeblement of the lower extremities, with "numbness" and "pins and needles," on the one hand, to complete paraplegia both motor and sensory, with priapism and retention of urine and feces, on the other. Not unfrequently, intense hyperæsthesia is also present, as was noted in the following very instructive case of concussion of the spinal cord in the cervical region, with ecchymosis of the left posterior horn of gray matter, of the right anterior horn, and of the posterior columns. The injuries resulted from a fall, and the case is related by Sir W. Gull:³—

A coal-porter, aged 33, slipped and fell down some cellar-stairs, with a sack of coal falling upon him. He was admitted at 3 P. M., June 22, after the accident; there was loss of motion in both legs and in left arm; the sphincters were paralyzed; sensation was entirely lost in left arm up to deltoid; sensation and motion in right arm perfect; in the lower extremities, he could feel about the feet and on the outer side of thighs, but not on the anterior and inner surface; slight priapism; breathing diaphragmatic. Sensation returned in every part after a few hours; the most distant parts apparently recovered first. As the skin became warm he complained of pain when lightly touched (hyperæsthesia). For instance, when the finger-nail was lightly passed over the skin he exclaimed, "Don't prick me; don't hurt me!" Next day, the cutaneous sensibility appeared to be excessive, judging from his exclamations when the skin was touched or pinched. This was noticed especially in the right arm. The priapism disappeared in two hours after admission, but returned on the day following; power to move the right arm remained; thirty-four hours after the accident the patient died. *Autopsy*.—There was no external trace of injury. The membranes of the cord were healthy. The substance of the cord was contused opposite the fourth and fifth cervical vertebræ. On section, there was found ecchymosis of the posterior horn of gray matter on the left side, and of the adjacent part of the lateral and posterior columns. There were also limited spots of ecchymosis on the right side, one in the right posterior column, and one in the right anterior horn of gray matter. The gray substance generally was hyperæmic. On removing the spinal cord and membranes, nothing abnormal was discovered in the vertebræ until the posterior ligament had been dissected off, when it was seen that the body of the fourth was separated from that of the fifth, and that the left articular process of the fourth had been chipped off.

The essential features of this instructive case are: (1) the cord-substance was injured by concussion, and not by any displacement of the parts; (2) the

¹ Op. cit., pp. 116, 117.

² Principles and Practice of Surgery, p. 177.

³ Guy's Hospital Reports, 1858, pp. 191, 192.

injury was attended by a number of minute extravasations of blood (ecchymoses) in the gray substance; (3) there were anæsthesia and loss of motion in both lower extremities and in the left arm; (4) there was paralysis of the sphincter ani and sphincter vesicæ, which denoted that the reflex motor apparatus was also paralyzed; (5) the anæsthesia passed away in the course of some hours, the return of sensibility being noted first in the parts most distant from the injury; (6) hyperæsthesia appeared synchronously with the reaction from "shock," and steadily increased in severity; (7) hyperæmia of the gray substance was found as well as ecchymosis. It should be remarked that the hyperæsthesia was more severe in the right arm than elsewhere, and that this part had not at any time been paralyzed.

It should also be noted that the hyperæsthesia was coincident in its appearance with the hyperæmia of the cord-substance which followed the injury, and that as the inflammatory excitement caused by the sanguinolent extravasations of blood into the cord-substance, or the hyperæmia, etc., increased or progressed, the hyperæsthesia also rapidly increased until thirty-four hours after the accident, when death occurred.

Treatment.—Inability to urinate and defecate will necessitate the employment of catheterization, and of enemata, or laxatives. When hyperæsthesia is present, it must be subdued by the administration of belladonna, or of opium or morphia. Dry-cupping the dorsal and lumbar regions has, in my own experience, proved very useful in cases of gunshot concussion of the spinal cord. At a later stage, counter-irritation by issues or setons has appeared to do good. But, quietude or rest for the injured spinal column and cord is an important reparative measure, in such instances, fully as important as any other. Not only should the patient be debarred from attempting to overcome his "numbness" and his "pins and needles" by exercise, which caprice or habit might lead him to do, but he must be kept in bed until these symptoms have passed away. Mr. Hilton¹ mentions the case of a gentleman who had sustained a moderate concussion of the spinal marrow from falling upon his back at Epsom, which resulted in irremediable paraplegia, from inattention to this curative measure. Should the symptoms of myelitis supervene, they must be combated by the remedies for that disease which will be mentioned further on.

CONTUSION OF THE SPINAL CORD.—Bruises of the spinal marrow, like bruises of the cerebrum, are attended by disintegration of the elementary tissues thereof, and minute extravasations of blood, or ecchymoses. There is, however, this important difference between them; for, inasmuch as the cineritious substance is mostly found on the exterior of the cerebrum and within the interior of the spinal marrow, so the ocular evidences of contusion are usually seen, most distinctly, on the exterior or cortex of the former, and within the interior of the latter; and it frequently happens that contusions of the spinal marrow are not discernible by the unaided eye, until the parenchyma thereof is laid open by an incision, and until the cineritious substance is thus exposed to view.

The slighter examples of contusion of the spinal cord, those in which the ecchymoses are not large nor numerous, are commonly, and almost unavoidably, classified, in practice, with the cases of concussion of the spinal marrow which have just been described, and in which the symptoms of spinal concussion constitute the chief clinical phenomena, and among which, at the bedside, no differential diagnosis between concussion and contusion of the spinal

¹ *Op. cit.*, p. 33.

marrow can be made. The following case, observed by Mr. Savory,¹ will serve to show what the symptoms are in severe contusions of the cord:—

A man fell upon his head from a railway van. During the first few minutes he was stunned, but this soon passed off. When admitted to hospital, there was complete loss of motion and sensation in the lower and upper extremities, and in the trunk nearly as high as the clavicles. The respiration was entirely diaphragmatic, the thoracic walls sinking inward at each inspiratory effort. No reflex action could be excited in the lower extremities, nor elsewhere. The pupils were moderately and equally dilated, but sluggish. There was partial priapism. Death ensued in about thirty hours. *Autopsy.*—There was no fracture nor displacement at any part of the skull or spinal column; there was also no hemorrhage nor material congestion at any part on the surface of the brain or spinal cord. But a longitudinal section of the spinal cord revealed, opposite the fourth cervical vertebra, a clot of blood which was extravasated in its substance to the extent of about half an inch. This extravasation was well defined, and nothing wrong could be perceived in the adjoining or in other parts of the cord.

In this case the functions of the spinal cord were completely abolished in two important particulars: 1. There was entire loss of sensation and voluntary motion. 2. There was also total absence of any reflex action. While the clot of blood, the product of contusion, which was found in the substance of the spinal cord at the autopsy, accounts satisfactorily for the former, it does not for the latter; for while the blood-clot might completely destroy the power of the spinal cord as a *conductor* of impressions, it could not destroy its functions as a *reflector* of impressions or as a nervous centre. And inasmuch as the loss of reflex action, observed during life, was due to destruction or impairment of the spinal cord as a nervous centre, it must, as pointed out by Mr. Savory, have arisen from the concussion to which the spinal cord was subjected by the accident, although it produced no effect on the structure of the cord that was visible after death.

This loss of reflex action in the spinal nerves, in consequence of concussion of the spinal cord, mentioned above by Mr. Savory, I had myself previously observed; and I specially noted it at the time of making the observation, although I did not then understand its rationale. The following abstract is taken from the note-book in which the minutes of the case were written at the time:—

Private John H. Rhodes, Company A, 16th Pennsylvania Cavalry, aged 22, was admitted from our front before Petersburg to the Depot Field Hospital, at City Point, December 14, 1864, for injury of the spine and paraplegia. On the 15th, I examined him with much interest. It appeared that he had been hurt, while lying face downward on the ground, on Sunday, the 11th, by the falling of a tree, some branches belonging to the top of which struck him violently across the back and shoulders. He was immediately deprived of the use of his legs and the lower half of his body. When I saw him, all the parts below the umbilicus were completely paralyzed, both as to sensibility and voluntary motility. The bladder required a catheter to be introduced twice a day; the urine was more abundant in quantity than natural. He passed a consistent stool unconsciously in bed on that day. "I failed to excite any sensibility or any reflex action by tickling the soles of his feet, or by pulling the hairs of his legs, thighs, or groins. Both extremities were alike in these respects." Above the umbilicus, sensibility gradually appeared in the skin, at first indistinctly, but increasing with the upward progress of the examination, until it became normal on the upper part of the thorax. The respiration was abdominal (diaphragmatic), and superior thoracic (superior intercostal). He had good use of both upper extremities, and made no complaint of them whatever. He was cautiously turned upon his right side, so as to permit an examination of his back. The consistent stool, above mentioned, was then found in bed. Before this, his bowels had not acted at the hospital. There was no appearance of contusion

¹ St. Bartholomew's Hospital Reports, vol. v. p. 45.

nor ecchymosis on the integuments of his back and shoulders. There was no deformity nor abnormal mobility found in the spinal column. There was moderate tenderness under pressure when made upon the vertebræ, at the upper part of the dorsal region. He did not complain of being hurt in any part while being turned over in bed. He had considerable cough, with expectoration; sputa unstained. His face had a dusky hue (not deep). He swallowed both solids and fluids without difficulty. Did not complain of distress in any part; no priapism. He died on Saturday the 17th, six days after the accident, from failure of the respiratory function.

Autopsy.—Among the muscles, near the upper dorsal vertebræ, a small quantity of blood was found extravasated, but no cutaneous ecchymosis. The laminæ of the first dorsal vertebra and the body of the second were fractured, with but little if any displacement; that is, there was a fissured fracture which extended through the laminæ of the first and the body of the second dorsal vertebra. The anterior common ligament was torn partly through, and the posterior common ligament was loosened or detached to some extent at the seat of fracture. Between the theca vertebralis and the bone, on the left side of the spinal canal, in the same neighborhood, a thin blood-clot was found. It was about two inches long by one-fourth of an inch in breadth, and did not compress the spinal cord. There was no extravasated blood within the theca vertebralis. The spinal cord, externally, presented no abnormal appearance whatever. It was not discolored, nor notched, nor lacerated. But, on making a longitudinal section, the gray substance of the interior was found to present an ecchymosed and contused appearance opposite the fracture, but not elsewhere. Here it was dark-brown in color from the extravasation of blood, and pulpified in consistence from the force of the contusion. These lesions were symmetrically developed. The spinal membranes and spinal cord were not inflamed. The lungs (both) contained more than the normal quantity of blood, that is, they exhibited passive hyperæmia, but in other respects they were sound.

This abstract touches all the essential points pertaining to concussion and contusion of the spinal cord. The blow struck by the falling tree upon this man's spinal column, as he lay face downward on the ground, suddenly bent it downward (that is, forward) at an acute angle, by severely stretching and so partly rupturing the anterior common ligament, and by making a rent or fissured fracture which extended upward through the body of the second and the laminæ of the first dorsal vertebra. The fragments immediately sprang back into place again. But the blow and the abrupt bending of the spinal column mortally injured the spinal cord. The elementary tissues composing its interior were disintegrated, or reduced to a pulp-like consistence, and were deeply stained with blood extravasated from the ruptured capillaries. The conducting power of the cord was totally destroyed either by the force of the blow itself, or by the pressure which the extravasated blood exerted upon the conducting fibres of the cord. Moreover, the concussion or "shock," which the spinal cord received from the blow, abolished its office as a distinct centre of the nervous system, over a large space, without leaving any alterations of structure whatever to account therefor, that were visible after death. Thus, the man was wholly deprived of reflex motor activity, as well as of sensibility and voluntary motion, in all the parts supplied with spinal nerves which depart from the cord below the lesion of its substance just described. The loss of reflex motor action in the paralyzed parts was as complete in this case, as it was in that which precedes it, and in both alike the post-mortem examination failed to reveal any anatomical cause. From the autopsies of cases such as these, the statement appears to be well founded, that concussion of the spinal marrow, unless it be complicated with contusion, is not attended by any structural change of the marrow which is discernible after death, with the unaided eye.

Anatomical Lesions attending Bruises of the Spinal Cord.—In such cases, the theca vertebralis is very rarely found torn; and, on laying it open, one might imagine the cord to be uninjured, in many instances, because the pia

mater of the cord remains entire and without ecchymosis, as it did in the cases just related. On slicing the cord, however, its substance is found to be crushed more or less completely through and through, and blackened by extravasated blood. Sometimes the cord-substance is utterly smashed and broken down into a diffuent pulp throughout a space one inch or more in length, while the pia mater over it remains entire. In other instances, ecchymosis is plainly visible on the outer surface of the cord. Occasionally, this ecchymosis is very considerable in degree and extent.

For instance, Lasalle¹ reports the case of a man, aged 36, and a maniac, who injured his neck by violently throwing his head forward, while struggling against restraint. His head remained bent forward, and there was spinal paralysis. Death ensued thirty-six hours afterward. *Necroscopy* showed that the intervertebral substance between the bodies of the fifth and sixth cervical vertebræ was torn through, without any fracture, and with but slight displacement of the implicated bones. Great ecchymosis, however, was found on the spinal cord.

Symptoms.—Besides the signs of spinal paralysis already mentioned, *e. g.*, the destruction of sensibility, of voluntary motion, and of reflex motor action, in the parts supplied by spinal nerves which issue from the cord below the bruise, another important symptom, namely, hyperæsthesia, is not unfrequently observed.

For example, Mr. Bryant² relates the case of a coal-porter, aged 33, who fell down stairs with a sack of coal on top of him, and broke his neck. He had spinal paralysis, priapism, and diaphragmatic breathing; but, after a few hours, hyperæsthesia came on. In thirty-four hours death ensued. *Necroscopy* revealed fracture and displacement of the fourth and fifth cervical vertebræ. The cord was contused but not compressed. The hyperæsthesia does not appear to have been caused by injury of the spinal nerves, but by changes that were taking place in the bruised part of the spinal cord.

There are not yet on record so many examples of contusion of the spinal marrow, with a full account of the symptoms and post-mortem appearances observed in each, that we can safely trust to generalizations drawn from them, and thus dispense with giving the particulars of the cases, when discussing the subject. The details of the following example are very instructive:—

Mr. South³ relates the case of an old man, aged 68, who was injured and stunned by falling down stairs, and who was admitted to St. Thomas's Hospital a few hours afterward: He had pain at the back of his neck, which was increased by pressure; all his limbs, except the left lower extremity, which still retained slight motion, were palsied; the sensibility of the whole right side of the body was morbidly acute, that of the left totally destroyed, excepting on the belly, where he felt slightly, and to which he referred a sensation of numbness when the left thigh was pinched. Next day he complained of pain in the right arm; the skin on the left side of the belly was less sensible. On the third day the morbid sensibility of the right side had diminished, and sensation had slightly returned on the left. He complained of pain in the right hypochondrium, and fancied that his arms lay across his chest. On the following day the belly became tympanitic. On the fifth day there was slight motion of the left arm, and the capability of moving the right leg had increased; but he was rapidly sinking, although in good heart, and died late at night. On *examination*, it was found that the atlas was broken in two places, the line of fracture being diagonal, and traversing the left vertebral hole. The pivot of the axis was broken off at its root, and a small piece of the body also. The fifth vertebra was fractured through the body. With neither fracture was there sufficient displacement to produce pressure. On cutting through the spinal cord a central cell was found, containing a small quantity of blood, and the substance of the spinal cord was broken down and disorganized opposite the fifth vertebra.

¹ Gazette Médicale, 1841.

² Guy's Hospital Reports, 3d series, vol. v.

³ Notes to Chelius's System of Surgery, vol. i. p. 585, Am. ed.

This patient survived the accident something less than six days. Both the hyperæsthesia and the spinal paralysis that were observed in his case, arose from the contusion of the spinal marrow, that is, from the disintegration of its elementary tissues, and the extravasation of blood therein, and from the secondary lesions of the marrow, hyperæmia and hyperplasia, which were induced by the injury. Still, as the absorption of the blood extravasated in the bruised part of the spinal cord progressed, the symptoms of spinal paralysis, *e. g.*, the loss of sensibility and voluntary motion, decreased in corresponding degree. The hyperæsthesia also varied from day to day.

To sum up the symptoms which present themselves in cases of contusion combined with concussion of the spinal cord, they are: loss of sensibility, loss of voluntary motion, and loss of reflex motor action in all the parts supplied by those filaments of the spinal cord which are directly or indirectly injured by the contusion of the cord, or which issue from the spinal cord below the seat of contusion, occurring suddenly and coincidentally with the injury of the cord itself; also hyperæsthesia which, not unfrequently, comes on some hours, or even days, after the injury has been inflicted.

Furthermore, concussions and contusions of the spinal cord, like dislocations and fractures of the spinal column, may be attended by very considerable deviations of the body-heat from the normal, both above and below, as was pointed out on page 335. Mr. Erichsen, in particular, has seen spinal concussion attended by marked and prolonged lowering of the vital temperature.

Contusions of the spinal marrow with extravasations of blood into the substance thereof, are of not unfrequent occurrence.

Besides the foregoing examples, M. Brown-Sequard¹ mentions a case by Walker, in which there was dislocation of the fourth cervical vertebra; an incision showed that there was no fracture. The dislocation was reduced, and the patient was improved thereby. Death, however, ensued in six days. *Necroscopy* revealed hemorrhage in the spinal cord.

Mr. Luke² relates the case of a laborer, injured by being knocked against the side of a ship, with which the back of his neck came in contact. Projection of the vertebræ in the neck, spinal paralysis, priapism, etc. were noted. In two days death occurred. *Necroscopy* showed fracture of the sixth cervical vertebra; the spinal cord was enlarged and softened; it also contained a blood-clot.

Mr. Solly³ reports the case of a plasterer, aged 40, who fell from a scaffolding, striking his head, and being stunned. There were paralysis of the right side, a scalp-wound, and a fractured clavicle. He died in forty hours. *Necroscopy* revealed fractures of the fourth and fifth cervical vertebræ; also hemorrhage into the spinal cord, which was soft and bruised.

M. Colin⁴ reports a case of hemorrhage into the spinal cord.

Treatment.—The therapeutical indications to be fulfilled in contusions of the spinal marrow are the same as in concussions of the spinal marrow, which have already been described.

COMPRESSION OF THE SPINAL CORD.—The nerve-fibres, ganglion-cells, and bloodvessels of the spinal cord, may be fatally compressed by blood when it is extravasated into the substance of the cord itself, into the spinal meninges (by intra-thecal hemorrhage), or into the spinal canal external to the theca vertebralis; also by the displacements of bone which arise from dislocations and fractures of the vertebræ, and by foreign bodies when they have

¹ Op. cit.

² Ibid., 1851.

³ Lancet, 1850.

⁴ L'Union Médicale, 1862.

entered the spinal canal; finally, the spinal marrow may be mortally compressed by the products of inflammatory action which are liable to be effused in all cases of spinal meningitis or myelitis.

Compression of the filaments and other elementary structures of the cord from blood extravasated into its substance, not unfrequently occurs, and examples in considerable number have been presented. But this subject has already been sufficiently discussed in connection with contusion of the cord.

Compression of the spinal marrow from hemorrhage within or upon its membranes has likewise been illustrated in many instances that have been presented in the foregoing pages. As extravasations of blood between the cranium and the cerebral dura mater, or into the cerebral meninges, often destroy life by compressing the brain, so extravasations of blood between the spinal column and the theca vertebralis, or inside of the sheath formed by that membrane, not unfrequently destroy life by compressing the spinal marrow. Mr. Hutchinson,¹ however, asserts that although much has been said about large effusions of blood into the spinal canal as a cause of paralysis, such effusions are, he believes, the rarest of occurrences, for he has "never seen any effusion to the extent of possible compression, and in the majority of cases there is little or none." That this eminent writer's belief on this important point is singularly inaccurate, many cases, already mentioned in this article, in which large effusions of blood were found in the spinal canal, on examination after death, bear strong testimony; and this evidence can be corroborated by presenting many others of a like nature. For instance:—

(1) Dupuytren² mentions the case of a soldier having a gunshot wound of the neck. There was almost complete paralysis. Death ensued twenty-four hours after the injury. The *autopsy* showed fractures of the fourth and fifth cervical vertebræ; cord unhurt; much blood effused in the spinal canal, and at the base of the brain.

(2) Murney³ reports the case of a laborer, aged 22, who fell from a scaffold twenty feet, striking his back. He walked to a neighboring house. In two hours paralysis began; priapism with retention of urine and feces followed; skin hot. Death occurred in four days. The *autopsy* revealed fractures of the fifth, sixth, and seventh cervical, and of the first dorsal vertebræ; no displacement; blood-clots on the spinal cord, which also was softened. (Ashhurst.) In this case, the coming on of paralysis some hours after the accident, and the gradual increment of the symptoms, kept pace with the sanguinolent effusion in the spinal canal.

(3) Hutton⁴ records the case of a man, aged 35, thrown from a cart into a ditch. There were "stunning," paralysis, and dyspnoea; and death ensued in four days. The *autopsy* revealed dislocation of the fifth from the sixth cervical vertebra, with slight fracture; cord softened; and extravasated blood. (Ashhurst.) In respect to symptoms and spinal-cord lesions, this case strongly resembles the last.

(4) A very great extravasation of blood occurred within the theca vertebralis in a case under the care of Dr. Stephen Smith, at Bellevue Hospital, some years ago. The patient was a healthy, temperate, and well-nourished derrickman, aged 41, injured by being thrown from a cart and striking his back upon the pavement; he was not rendered unconscious, and did not feel hurt until some one attempted to raise him; then he found that he was paralyzed, and that motion caused him intense pain.

On October 12, P. M., he was admitted to the hospital, two hours after the injury, in a state of collapse; pulse too frequent and feeble to be counted; respiration 18. There were complete sensory and voluntary-motor paralysis of the lower extremities and body up to the sixth intercostal space; moderate priapism; normal temperature. The subjective symptoms were severe pain in the back of the neck, and pain, numbness, and tingling in the arms. Objectively, nothing abnormal was found in the cervical region; but, in the dorsal region, a depression was discovered between two spinous

¹ London Hospital Reports, vol. iii. 1866.

² Dublin Medical Journal, vol. xxiv.

³ Op. cit.

⁴ Ibid., vol. xvii.

processes in which two fingers could be laid; no corresponding abrasion or ecchymosis visible. A free administration of stimulants, with an anodyne and catheterization, were ordered.

On the 13th, A. M., pulse 112; respiration 26, and mainly abdominal; temperature of trunk and lower extremities exalted. The anæsthesia had progressed upward, having risen to the fifth rib. The pain and numbness of the neck and arms had decidedly increased. The penis was not erect, but it was easily excited on irritating the spine. P. M., sloughs had commenced upon the heel and upon the ball of the great toe of the left foot, and over the external malleolus of the right ankle. A consultation was held, and resection of the depressed dorsal laminae was agreed upon, and at once performed under chloroform. An incision six inches in length, made in the line of the spinous processes, showed a depression of the arch upon the right side of one of the lower dorsal vertebrae. After some difficulty, the arch was divided on the opposite side, and then the depressed laminae were pulled out by a duck-billed forceps. Through the opening thus made, from six to twelve ounces of dark-colored, extravasated blood flowed out of the spinal canal. No benefit resulted from the operation, and death occurred soon afterward, apparently from compression of the spinal cord.

The *autopsy* revealed fracture of the body of the tenth dorsal vertebra upon the right side, extending from the base of the transverse process half way to the mesial line anteriorly, without displacement; fracture of the arch of this vertebra upon the right side, with depression; extravasation of blood within the theca vertebralis to a large amount, and extending from the lower cervical vertebrae to the sacrum. From the increasing paralysis it was inferred that this extravasation was still extending upward when the patient died.¹

This man's accident showed so many things clinically and experimentally, that the history of it is well worth the space consumed. It illustrated compression of the spinal cord, with ascending paralysis from intra-vertebral effusion of blood; it proved that neuropathic sphacelus may simultaneously appear at several different points in the extremities within twenty-four hours after the injury to the spinal cord; it illustrated the inutility of vertebral resection; and it proved that the operation of trephining the spine will not relieve the cord from compression arising from blood effused upon it.

(5) J. Jardine Murray² reports the case of a woman, aged 62, thrown from a carriage. There were paralysis and retention of urine, and next day coma; in twenty-four hours death occurred. The *autopsy* showed fractures of the fifth and sixth cervical vertebrae; spinal canal filled with clotted blood; cord unhurt. (Ashhurst.)

(6) Ch. D. Doig³ relates the case of a porter, aged 37, who fell into the hold of a steamboat, and hurt his neck. There were pain, paralysis, dyspnoea and dysphagia, retention of urine and feces, and insomnia; in four days, death ensued. The *autopsy* revealed fracture and dislocation of the fifth cervical vertebra; clotted blood effused on the spinal cord; cord itself unhurt. (Ashhurst.)

(7) W. T. King⁴ reports the case of a laborer, aged 25, thrown from a cart with his neck across a hammer. There were paralysis, etc.; death occurred in fifty hours. The *autopsy* showed dislocation forward of the sixth cervical vertebra; no fracture; and blood extravasated around the spinal cord. (Ashhurst.)

(8) Holt⁵ records the case of a man, aged 45, injured by a horse falling upon him. Paralysis came on in the following night; but no cerebral symptoms. In seven days death ensued. The *autopsy* revealed fracture of the fifth, sixth, and seventh cervical vertebrae; blood effused into the spinal canal, and had fallen to the bottom of it; spinal cord uninjured; a tumor in the cerebellum. (Ashhurst.)

(9) Charles Bell⁶ mentions the case of a man who fell from a barge into the Thames, at low water. His head stuck in the mud, and he died instantly. Subluxation of the

¹ New York Journal of Medicine, January, 1859, pp. 87, 88.

² Edinburgh Medical Journal, N. S., vol. vii.

³ Ibid., vol. ix.

⁴ Lancet, 1849.

⁵ Ibid. 1850.

⁶ Observations on Injuries of the Spine and Thigh-bone

seventh cervical upon the first dorsal vertebra was found, and effusion of blood. (Ashurst.)

(10) Malgaigne¹ refers to the case of a carter, injured by a wheel passing over his neck and shoulder. There were pain, paralysis, etc. In thirty-one hours death occurred. The *autopsy* showed subluxation of the sixth cervical vertebra, with slight fracture. The spinal cord was stretched, and blood effused.

(11) Sir W. Gull relates the following case :² A man, aged 40, fell backward from a moderate height with a plank on top of him, and was at once brought to the hospital (4 P. M., July 7). He was collapsed, but sensible, and partially paralyzed in the upper as well as in the lower extremities. No injury of spine discoverable. As reaction came on, and he grew warm again, the paralysis wore off. At 10 P. M. he said he was comfortable. He passed a restless night. At 8 A. M. (July 8) he was entirely paraplegic in the upper as well as in the lower extremities; sensation lost as well as motion; priapism; abdomen tense and tympanitic; the breathing was wholly diaphragmatic; the ribs scarcely moved in inspiration; deglutition difficult; temperature of the surface increased; during the day the skin became intensely hot, but the actual temperature was not noted; fifty-five hours after the accident death ensued. *Autopsy*.—No external evidence of spinal injury. "Extravasation of blood outside the theca vertebralis, on its anterior aspect. The effused blood compressed the cord, which otherwise was uninjured. After careful examination there were not found any signs of bruising of its tissue. The extravasation apparently arose from injury to the lower part of the body of the fourth cervical vertebra, which had been fractured, and the intervertebral substance torn. The calibre of the canal was slightly encroached upon by the displacement of the fourth vertebra, but not so as to press on the cord. The extravasation, though not abundant opposite the injury, extended downward to some distance. The membranes of the cord were uninjured." The interspinous and capsular ligaments between the fourth and fifth cervical vertebræ were torn through, and the articular processes dislocated.

It is worthy of remark (1) that the symptoms of paralysis which arose from the "shock" or concussion of the spinal cord, in this case, passed off in a few hours; (2) that there supervened a paralysis, both motor and sensory, which gradually increased until it became complete and extended up to the neck, and which was shown by necroscopy to have resulted from the effusion of blood in the spinal canal between the theca and the bone; and (3) that the substance of the cord did not exhibit any appreciable lesion, notwithstanding the compression it had sustained from the sanguinolent effusion.

Were it essential to a correct exhibit, additional examples might be cited, but these eleven cases, together with some twenty others which have already been related or referred to above, are enough to prove beyond a doubt that compression of the spinal marrow arising from hemorrhage into the spinal canal is not a rare occurrence, as asserted by Mr. Hutchinson; and, furthermore, that any surgeon, however large his practice may be in this class of injuries, is liable to fall into errors of belief concerning them, when he generalizes solely from his own experience.

The *diagnostic symptom* of cord-compression, when it arises from the extravasation of blood in the spinal canal, is paralysis of sensation and voluntary motion, commencing in the legs a few hours after the accident, and gradually extending upward to the chest and neck, as the extravasation progresses upward in the spinal canal, and *pari passu* with the same.

M. Brown-Séquard states, in his Dublin Lectures, that hemorrhage into the substance of the spinal cord may be distinguished from hemorrhage around it, by the sensibility gradually decreasing, and by there being no convulsions. When the hemorrhage is merely around the cord, and compresses the roots of the spinal nerves, there are convulsions, as well as paralysis of voluntary motion.³

¹ Traité des Fractures et des Luxations, t. ii.

³ New Sydenham Soc. Year-Book, 1859, p. 41.

² Guy's Hospital Reports, 1858, p. 193.

Compressions of the spinal marrow, arising from the displacements of dislocated and fractured vertebræ, have already been mentioned with sufficient particularity while presenting illustrative examples of the spinal dislocations and fractures which produce them.

Compression of the spinal cord by foreign bodies which have entered the spinal canal, will be sufficiently illustrated by the subjoined abstract and wood-cut (Fig 878):—

A soldier, aged 40, wounded May 8, 1864, was admitted to a General Hospital on the 18th, in a paralytic condition, and died a few hours afterwards. *Necroscopy*.—A conoidal musket-ball entered over the lower ribs on the left side, and, penetrating deeply, had lodged between the laminae of the second and third lumbar vertebræ and partly in the spinal canal, compressing and bruising the cord. (Fig. 878.) The bladder was distended.¹

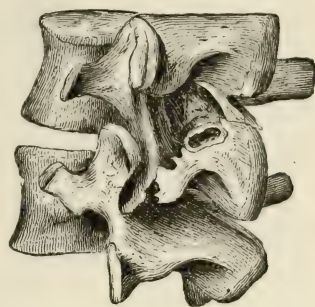


Fig. 878.
Showing the second and third lumbar vertebræ, with a conoidal musket-ball lodged between their laminae, projecting into the spinal canal, and compressing the cord. (Spec. 3523, A. M. M.)

Compression of the spinal marrow by the products of inflammatory action, as, for example, by serous and by purulent effusion, will presently be discussed under the heads of *Traumatic Spinal Meningitis*, and *Traumatic Myelitis*.

WOUNDS OF THE SPINAL CORD.—Incised and punctured wounds of the back, which penetrate the spinal column, as well of those made by gunshot missiles, sometimes involve the spinal cord also, and divide it either partly or wholly. Three cases, in which incised or punctured wounds of the back extended into or across the spinal cord, have already been related. (See pp. 269, 270.) In all of them the parts supplied by the cut filaments of the cord were paralyzed. Two recovered (one completely, the other partially) and one died. Inasmuch as the patient who recovered completely, had, for some time after the wound was inflicted, entire loss of voluntary motion and partial loss of sensibility in the right leg and thigh, it was believed that the divided portion of the cord had grown together again, or united, in the course of about two months, when the paralysis ceased *in toto*, and the cure was perfect. In the fatal case there was complete paraplegia, both motor and sensory, from the moment the wound was inflicted. Acute bed-sores (sphacelus) soon supervened, and caused death in thirty-six days after the injury. The cord had been completely divided by the knife, and there was no attempt at reunion.

Dr. Eli Hurd² reports a remarkable case of recovery from an incised wound of the spinal cord:—

In jumping from a wagon, the man's feet slipped, and he fell on his back. In attempting to rise he found his lower extremities paralyzed. Calling for help he stated that a chisel, which he had carried in his coat-tail pocket, was sticking in his back; to extract it, required the united efforts of several men. It measured five inches in length to the shoulders, was seven-eighths of an inch in width, and from one-fourth of an inch at the shoulders tapered to one-eighth of an inch in thickness at the cutting end. It had entered to the shoulders. During the extraction, the patient suffered very little, but said that he saw apparently vivid flashes of light, which were followed by total darkness. The wound was opposite the spinous processes of the lower dorsal vertebræ. Total loss of cutaneous sensibility below the wound, with total loss of voluntary motion

¹ Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 447.

² New York Journal of Medicine, 1845.

in the corresponding parts, and paralysis of the bladder and rectum, were the immediate consequences. The patient was prostrated for forty hours, and then reaction was followed by fever for several days. The wound healed rapidly. The urine was withdrawn by a catheter for eight days. Cutaneous sensibility returned on the fifth day, and imperfect use of the limbs about the fifteenth. After five years he still walked with crutches.

Dr. Hurd fully believed that the spinal marrow was divided in this case, and that afterward it united or grew together again.

Dr. T. Peniston¹ relates another successful case:—

A man, aged 34, received a stab-wound from a dagger between the eleventh and twelfth dorsal vertebræ, on the right side. It was attended by paralysis of the right leg. In eight months he recovered so far that he walked with a cane or crutch. (Ashhurst.)

The following example is very instructive as well as interesting:—

M. Viguès² reports the case of a man, aged 28, who was admitted into Professor Nélaton's ward, at the St. Louis Hospital, on February 4, 1850, shortly after he had been wounded in the back with a sword by a police-officer. The point of the weapon, entering three centimetres (one inch) from the line of the spinous processes and to the right thereof, and making a transverse cut one centimetre and a half (half an inch) in length, passed obliquely toward the left and a little upward, between the ninth and tenth dorsal vertebræ, into the spinal canal, and wounded the spinal cord. There were paralysis of the lower extremities, with retention of urine and feces, and marked hyperæsthesia of the left lower limb and genital organs. On February 20, a slough was found on the right side of the sacrum; the patient had not felt anything there. In April, voluntary motion had returned in both limbs, but sensibility was still deficient in the right. On June 15, the patient could walk with the help of a cane; and he left the hospital, although the sensibility was not yet fully restored in his right limb. Three years afterward the patient was again seen; he stated that he was quite well, and that he could walk without difficulty or fatigue; but, a year later, having walked a distance of many leagues, he found a large eschar, produced, he said, by the friction of his pants on his right knee; he had felt no pain, and was surprised when he found this sore. Although the sensibility was still deficient in this limb, its movements were all executed freely and without fatigue.

Without doubt the weapon, in this man's case, gashed the spinal cord extensively, and the severed nerve-filaments reunited in a comparatively brief time. Here is still another successful case of the same sort, which was recorded by Morgagni:—³

A young man was struck with a quadrangular and acute poniard, which entered his neck below the left ear, and passed into his spinal cord. Immediately, sensibility and voluntary motion were lost in all the parts below the head. The respiration was entirely diaphragmatic. He complained of being cold; and, without his feeling it, the application of a hot metallic vase caused burns on his thighs, legs, and feet. On the seventeenth day, he began to recover some feeling in the left side of his body; and, on the twentieth, he began to move the toes and fingers of the same side; these faculties gradually increased. On the thirty-second day, there was a return of some feeling in the right side of his body; movement also, but at a later period, returned slowly there. On the fortieth day, there was sensibility and movement everywhere, but not enough to allow the patient to stand up. The recovery was so slow that, four months after the casualty, he was just beginning to get out of bed, and to walk as a child learning to walk; and, even then, there was less capacity for feeling and movement in the right than in the left side of his body.

¹ New Orleans Med. and Surg. Journal, 1851.

² *Moniteur des Hôpitaux*, 3 Septembre, 1855, p. 838; Brown-Séquard, *op. cit.*, pp. 97-100.

³ *De Sedibus et Causis Morborum*; quoted by Brown-Séquard, *op. cit.*, pp. 103, 104.

It should be observed that the complete loss of sensibility and voluntary motion, which occurred at the outset of this case, arose from the intra-theal extravasation of blood and consequent compression of the spinal cord, as well as from the section of certain parts of the cord itself by the poniard. No doubt, the severed nerve-fibres reunited in this case also; and the clinical history clearly shows how very slow the process of reunion sometimes is.

But incised and punctured wounds of the spinal cord may give rise to inflammation of the cord and its membranes, and so cause death, as happened in the following instance:—

M. Gama¹ relates the case of a soldier who received a bayonet wound between the twelfth dorsal and first lumbar vertebrae, which injured the spinal cord. On the seventh day he died, without having had any paralysis. There was at the outset pain, which diminished after several venesections. On the second day, however, he had the most excruciating pains and violent cramps in all the parts below the wound, and they continued until his death. There was also extreme hyperæsthesia, and the skin on the lower part of his trunk and inferior extremities was so sensitive that one did not dare to touch him, and he had to keep himself on his knees and hands. *Necroscopy* revealed a wound of the spinal cord. There was an inflammation of the spinal cord and its membranes, and also of the brain.

The pains and cramps in the legs, etc., arose from the meningeal inflammation involving the contiguous spinal nerves. The hyperæsthesia, however, arose in part from this cause, and in part from the inflammatory lesion of the spinal cord, but mostly from the latter. Brown-Séquard has ascertained by experiments upon animals, that a wound on the posterior surface of the cord is followed by a greater hyperæsthesia, in the lower limbs, when made at the middle of the enlargement whence the spinal nerves proceed to these limbs, than when it is made higher.

In *unilateral injuries* of the spinal cord, there is often observed a loss of voluntary motion on the same side of the body, with a loss of sensibility on the opposite side. This point is an important one, and can best be illustrated by presenting the abstracts of a few cases:—

Dr. F. Riegel² records the case of a man, aged 22, who was stabbed in the neck with a knife. After being insensible for some time, he presented the following symptoms: On the left side of the body, there were paralysis of all the muscles excepting those of the head and neck, augmented sensibility to touch, changes of temperature, and pain, and increase of reflex irritability; at a later period, there was atrophy of the paralyzed muscles, with corresponding thermometric changes. On the right side of the body there was almost entire anæsthesia as regards all forms of sensation, with complete power of motion. From the symptoms, Riegel concludes that the left half of the spinal cord was divided in the neck. The tremors and reflex irritability were successfully treated with hypodermic injections of arsenious acid. M. Bernhardt gives a case of the same kind.³

Boyer⁴ mentions the case of a drummer who was wounded in the back of the neck by a sword thrown at him, which penetrated the upper part of the right lateral half of the neck. An incomplete motor paralysis ensued in the right side of the body; and, it was accidentally discovered some time afterward, that sensibility was lost in many parts of the left side. After twenty days, the wound was cured and the man left the hospital, but he was still paralyzed.

Dr. J. Hughlings Jackson⁵ reports a stab-wound of the cervical region involving one side of the spinal cord. There were loss of motion and ptosis on the same side as the lesion, and loss of sensation on the opposite side.

¹ *Traité des Plaies de la Tête et de l'Encéphalite*, 1830, p. 318; Brown-Séquard, *op. cit.*, pp. 60, 61.

² *Berlin klin. Woch.*, 1873.

³ *New Sydenham Soc. Biennial Retrospect*, 1873-74, p. 123.

⁴ *Traité des Maladies Chirurgicales*, t. vii. p. 9; Brown-Séquard, *op. cit.*, p. 101.

⁵ *London Hospital Reports*, vol. i. p. 337.

Treatment.—Incised and punctured wounds of the spinal marrow should be treated by closing them immediately with antiseptic precautions, and with antiseptic dressings applied on the outside, in order to get union of the external wound by “the first intention,” and thus stop the outflow of cerebro-spinal fluid as soon as possible. To promote the same end, the injured parts should be kept in a state of rest, as nearly perfect as possible. By employing these means, too, the occurrence of spinal meningitis or myelitis may be obviated. It will be remembered that, in a case, mentioned above, of bayonet-wound of the spinal cord, traumatic meningitis supervened, and destroyed the patient. All pains that arise in such cases should be subdued by administering opium or morphia.

Gunshot wounds of the spinal cord are of frequent occurrence. In nearly all the examples of gunshot fracture of the spinal column, which have been above presented to the reader, traumatic lesions of the spinal cord also existed. In the case of Soteldo (p. 374), the missile slightly lacerated the cord, and deposited in its substance a spiculum of bone. In the soldier's case reported by M. Hutin, where there was survival of the injury for fourteen years, death resulting from Bright's disease, the missile divided the right half of the cauda equina, displaced the left half, and became itself firmly impacted in the spinal canal, where it remained innocuous for the time specified. In several instances above mentioned, the missile completely divided the spinal marrow.

To illustrate the phenomena which result from gunshot wounds of the spinal cord, it is advisable to narrate the history of a case that came under my own observation:—

Sergeant A. S. Girt, Co. E, 4th Pennsylvania Cavalry, aged 23, was wounded December 1st, 1864, by a pistol-shot which entered the root of his neck about an inch above the inner end of the left clavicle, passed backward, downward, and inward to the spinal column, perforated the body of the first dorsal vertebra, wounded the theca vertebralis and the spinal cord, fractured the laminae of the second dorsal vertebra, and lodged on the right side of its spinous process. He was standing at the time, but instantly fell to the ground in a helpless condition from paraplegia. The wound bled considerably at first, but the bleeding soon ceased spontaneously. On the 2d, I saw him at the field-hospital of the Cavalry Division in front of Petersburg, Va. The orifice of the wound was remarkably small, and the integuments surrounding it were considerably swelled and tender, that is, inflamed. There was complete paralysis, both sensory and motor, of the lower extremities, and of the abdomen as high as the umbilicus. He had no power of voluntary motion whatever in those parts. Likewise, I failed to excite any reflex movement whatever by tickling the soles of his feet, and did not produce any sensation by violently pulling the hairs on his legs, thighs, etc. The urinary bladder also was paralyzed, and catheterization was necessary. He had priapism. There was faint cutaneous sensibility just above the umbilicus; and, proceeding upward, this gradually increased until on the thorax it appeared to be normal. His respiration was superior-thoracic and diaphragmatic, or abdominal, but principally the latter. The sensibility of the upper extremities did not appear to be impaired, but the muscular power was considerably diminished, as I readily ascertained by grasping his hands and allowing him to pull. The left arm was weaker than the right. His intellect was undisturbed, and he did not complain of any pain, excepting when the wound and its vicinage were manipulated. On the 5th, I again saw him. He was smoking his pipe as he lay in bed; countenance cheerful, and free from any sign of distress; he said his appetite was good, and that he swallowed without difficulty. The wound was scabbed over, and the parts were less swelled and inflamed. His bowels acted spontaneously in the bed, and he had no control over them whatever, for the sphincter ani had ceased to act. The priapism had disappeared, but the condition of the bladder and other parts, as to paralysis, was unchanged. The respiratory function was quite successfully performed. On the 10th, he was transferred to the Depot Field Hospital at City Point. On

the 11th, a dusky hue of the countenance was observed, as if the blood were imperfectly aerated. On the 12th, the breathing became labored and attended with moist râles. The dyspnœa increased; and, on the 13th, he died. An *autopsy* was made by myself on the 15th. The missile had penetrated the root of the neck as stated above, gone through the sterno-mastoid muscle, and, avoiding the great vessels, struck the body of the first dorsal vertebra well in front and slightly to the left of the middle line, bored a hole through the body of this vertebra backward, downward, and toward the right, penetrated the spinal canal, lacerated the theca vertebralis on its front and right sides extensively, cut the spinal cord partly in two, fractured by its impact the right lamina of the second dorsal vertebra, with comminution (it had also fractured indirectly the left lamina), and lodged on the right side of the spinous process of the same vertebra, having passed through the spinal column from before backward, and somewhat obliquely from left to right and from above downward. The fragments were small and did not press upon the cord. The lungs held somewhat more blood than normal, were also moderately œdematous, and the air-passages contained a quantity of frothy unstained liquid. There was moderate inflammatory action, adhesive in character, in the theca vertebralis. It was confined, however, to the immediate neighborhood of the wound. There was no pus. The undivided portion of the cord was pulpefied (contused), and stained with blood, but it did not appear to the unaided eye to be inflamed.

The autopsy of this patient shows that gunshot wounds of the spinal cord are essentially contused and lacerated in their nature, while his clinical history exhibits the symptoms of concussion, contusion, and laceration of the cord, as might reasonably be expected. The loss of sensibility and voluntary motion below the cord-lesion, indicates that the functions of the cord as a conductor of impressions to and from the sensorium were entirely destroyed by the wound, and the loss of reflex motor action shows that the functions of the cord as a nerve-centre were likewise suppressed by the concussion.

When bronchial effusion with moist râles occurred in this case, the man could not get rid of it by coughing and spitting; and, therefore, his dyspnœa rapidly increased until death from suffocation took place. It is worthy of remark that, when complete paraplegia results from injury of the spinal cord at the root of the neck, the power of inspiration is generally preserved, but the power of expiration, as needed particularly for coughing and shouting, is entirely lost.

The traumatic lesions of the spinal cord that result from simple fractures and dislocations of the vertebræ, consist of contusion, stretching, laceration, and complete division. Many examples have already been presented. In Mr. Cline's famous case of resection or trephining the spinal column, the cord was found to be three-fourths torn through, and the remaining portion was bruised. Occasionally, the cord is found to be lacerated in the manner depicted in the accompanying wood-cut (Fig. 879). It represents the appearance which the spinal cord and membranes presented in the case of a soldier whose spinal column was fractured by the limb of a tree falling across his loins. A wood-cut to illustrate the vertebral lesion (transverse simple fracture of the first lumbar vertebra) was given on p. 351, *supra*, Fig. 862, together with the clinical account of the case. Necroscopy showed that the spinal meninges were torn entirely across, excepting a few

Fig. 879.



Showing laceration of the spinal membranes and cord caused by simple transverse fracture of the first lumbar vertebra. (Spec. 150, Sect. I, A. M. M.).

fibres anteriorly and posteriorly, and were congested above and below the rent. Clots of blood were found diffused near the fracture. The lower portion of the cord, severely lacerated, was drawn up into a bundle at the seat of injury, entirely deprived of the membranes. The tubular nerve filaments were seen to be curiously dissected out by the pus in which the cord was bathed, forming a leash which is well shown by the preceding wood-cut. Briefly stated, the vertebral lesion consisted of a transverse fracture extending through the body and pedicles of the first lumbar vertebra, with its spinous and left transverse processes impinging upon the cord. The latter may have been driven into that position by the force of the original blow, as well as by injuries sustained in transportation.¹ The cause of death apparently was septicæmia arising from gangrenous bed-sores.

Occasionally, too, the cord is completely severed by a vertebral dislocation or fracture. For instance:—

Malgaigne² mentions a case by Melchiori, in which a mason fell from a height upon his back. There was complete forward bilateral dislocation of the tenth dorsal vertebra. He survived the injury for one day only. The *autopsy* showed that there was no fracture, but that the spinal cord was divided. (Ashhurst.)

Dr. Parkman³ presented to the Boston Society for Medical Improvement, a specimen in which the third, fourth, and fifth dorsal vertebræ were fractured; the third and fourth were also displaced or projected in front of the sixth and seventh, and were co-ossified in that position. The cord was completely divided; still the patient survived for two months.

In very rare instances, a splinter from a fractured vertebra severs the spinal marrow, as happened in a case related by Abernethy, already mentioned, and in the following:—

Dr. D. S. Conant⁴ reports the case, already mentioned above, of a man, aged 55, who was blown off from rigging by wind, and who struck on his shoulders. There were fractures of the last dorsal and first lumbar vertebræ, paralysis, chill, and delirium. Blisters formed on both thighs, before death, which occurred in six days. The *autopsy* showed that a splinter from the first lumbar vertebra had divided the cord. (Ashhurst.)

It may be of interest to state that, in nearly all the fatal cases of dislocation or fracture of the spinal column collected by Mr. Bryant at Guy's Hospital, the vertebral injury was complicated with some structural lesion of the spinal cord; and that, in at least three-fourths of these fatal cases, the cord was irreparably injured by the mechanical pressure of the displaced bones, or by the effusion of blood into its structure.⁵

It is believed, however, that, under favorable circumstances, the nerve-fibres when divided in lacerations (incomplete) of the spinal cord from simple fractures and dislocations, as well as in incised wounds, may unite again, provided that they are not displaced too much, just as the filaments unite again in the nerves of the face and extremities, when divided by accidental wounds or by surgical operations. To support this view, the condition of the cord which was revealed by post-mortem examination, several months after the original accident, in a case recorded by Dupuytren of vertebral fracture with injury of the cord and paralysis, where recovery had taken place, may here be cited:—

Charles Millié, aged 21, was admitted to the Hôtel-Dieu, in 1825, with paralysis of the extremities and bladder, caused by a fall upon the back of his neck. After two months and a half of entire rest, combined with venesection, cupping, and leeching, he recovered,

¹ Medical and Surgical History of the War of the Rebellion, First Surgical Vol., pp. 426, 450.

² *Traité des Fractures et des Luxations*, t. ii.

³ *American Journal of the Medical Sciences*, N. S., vol. xxv. 1853.

⁴ *American Medical Times*, 1861.

⁵ *Lancet*, April 6, 1867.

and left the hospital with only slight weakness in the left leg, and with the head bowed slightly forward.

Subsequently he fell and broke his spine again. Thirty-four days after that he died exhausted from bed-sores and colliquative diarrhœa.

The *autopsy* revealed fractures of the fourth and fifth cervical vertebræ, which had united; the callus had been broken by the second fall. "Opposite the point of compression, the cord exhibited an annular constriction, abrupt and well-marked, and very analogous to that presented by the intestine in some cases of strangulated hernia. When incised longitudinally at this spot, the color and consistence of the cord were found altered to a brownish hue, and to the density and firmness of fibrous tissue; a small circumscribed spot, about a line in extent, was especially characterized in this way. The membranes were also more adherent here than elsewhere." It was inferred that the seat of this peculiar change was that of the original lesion of the cord, and that the morbid appearance constituted a true cicatrix of the spinal marrow.¹ Moreover, this case shows that the process of re-uniting the filaments of the spinal cord, when lacerated by vertebral fractures or dislocations, is not a rapid one, and that certainly several months, and possibly several years, must elapse before it can be accomplished.

M. Brown-Séquard's experiments upon animals prove that in them reunion may take place after a wound of the spinal cord, so that its lost functions may return.² Furthermore, this eminent observer has sometimes seen a notable return of lost functions (rachidian) in animals, when their spinal columns had been fractured and their spinal cords crushed.³ The investigations of MM. Masius and Van Lair,⁴ in regard to the regeneration of the spinal marrow, show how great the reparative power of this organ really is. These experimenters divided the spinal marrow in frogs, and at the end of from two to four months obtained undoubted evidence that these frogs had regained sensibility and voluntary motility in their hind legs. In other frogs, histological examination showed a more or less complete regeneration of the spinal marrow.

The fact that cases of long-standing infantile spinal paralysis are cured—cases in which there can be no doubt of the existence of the spinal lesion (atrophy of the anterior cornua)—is of itself sufficient evidence to prove that the reparative power of the spinal cord is very great. (Hammond.) Likewise, it will be remembered that four examples of reunion of the spinal cord in the human subject, when it had been gashed by cutting instruments, were presented on pages 393, 394 (*supra*). There can therefore, be no doubt, that the nerve-filaments of the spinal cord may reunite when they have been severed by simple fractures and dislocations of the spinal column.

The *treatment* which such wounds of the spinal cord require, has already been laid down while discussing the simple fractures and dislocations of the spinal column that cause them. Briefly stated, it consists, (1) in withdrawing the vulnerating body from the cord-wound by reducing the fracture or dislocation; (2) in placing the severed cord-filaments in the condition most favorable for reunion by maintaining perfect rest of body; and (3) in turning aside any phlogosis which would retard or prevent their reunion, by leeching or cupping, cold applications, and counter-irritants, used externally, and by opium or morphia, potassium iodide, and ergot, given internally, according to the indications for their employment.

INJURIES OF THE SPINAL NERVES.⁵—In fractures and dislocations of the vertebræ, whether simple or compound, the roots of the spinal nerves are

¹ Op. cit., pp. 358, 359.

² Experimental Researches applied to Physiology and Pathology, p. 17. New York, 1853.

³ Lectures on the Physiology and Pathology of the Central Nervous System delivered before the Royal College of Surgeons of England, p. 250. Appendix. Philadelphia, 1860.

⁴ Archives de Physiologie, t. iv. p. 268.

⁵ See Figure 877, p. 382.

liable to suffer injury during their passage through the intervertebral foramina. Such lesions were undoubtedly present in many examples of these fractures and dislocations which have been mentioned in the foregoing pages; but there is special ground for believing that such lesions were present in those cases of spinal fracture or dislocation where great pain was experienced by patients in the regions of body supplied by the spinal nerves which leave the spinal column at the seat of the displacement (*e. g.*, in the walls of the abdomen at the pit of the stomach, when the sixth or seventh dorsal vertebra is broken or displaced, etc.); for when the peripheral nerves in general are mechanically irritated in any part of their course, painful sensations or increased sensibility (hyperæsthesia) are usually produced in the parts where they terminate, and, when they are divided, these parts immediately become paralyzed, and their paralysis lasts until the severed nerves have grown together again.

The traumatic lesions which the spinal nerves most frequently sustain at the intervertebral foramina, are such prickings and scratchings of their component threads as cause pains (often severe), or increased sensibility, in the integuments and muscles of the back, where the posterior branches of the injured nerves are distributed, as well as in the integuments and muscles which are supplied by the anterior branches of the injured nerves. Sometimes cramp and other signs of convulsive action are experienced in the parts supplied by the injured nerves. Occasionally the spinal nerves are severed by the displaced bones in cases of vertebral fracture or luxation, and then the parts supplied by them are at once deprived of all sensation, as well as of all power of both voluntary and reflex motion.

Stromeyer mentions an interesting case in which the phrenic nerve must have been contused by a bullet, for during eight days great dyspnœa was present, and the patient was obliged to remain in a sitting posture; it was at first supposed that the lung had been injured, but there were no physical changes on the corresponding side of the chest.¹

This matter of severe pain being felt in the peripheral extremities of the spinal nerves, when they are injured by fractures or dislocations of the spinal column, is beautifully illustrated by the case of a colored soldier of our army, who received from the conoidal ball of a Colt's navy revolver, January 28, 1866, fractures of the spinous processes of the sixth and seventh dorsal vertebrae, laying open the spinal canal between these processes, and lacerating the cord; for he had great pain in the epigastric region, as well as complete paralysis below the seventh dorsal vertebra.²

TRAUMATIC INFLAMMATION OF THE MEMBRANES AND SUBSTANCE OF THE SPINAL CORD.

There are at least two considerable errors which have been long and widely taught by surgeons in English-speaking countries, as well as in others, namely: (1) that when the vertebrae are displaced in luxations and fractures of the spinal column, no effort should be made to restore them to a normal position, that is, that a dislocated or broken spine should not be "set;" (2) that when the spinal membranes and spinal cord, whether separately or collectively, are injured, they are by no means liable to take on inflammatory action, that is, that traumatic inflammation of the spinal cord-substance, and traumatic

¹ Stromeyer, Gunshot Fractures etc.; translated by S. F. Statham, p. 37. Am. ed.

² Circular No. 3, S. G. O., August 17, 1871, p. 38.

inflammation of the spinal meninges, occur so very rarely in cases of vertebral injury, that no special thought nor pains need be taken to avert them while conducting the treatment of such cases. The first-mentioned error has already been sufficiently refuted in the foregoing pages. It is now our duty to inquire into the second. In the first place, it should be said that the last-named mistake can have arisen only from the comparatively great infrequency with which the precise condition of the spinal cord and spinal membranes is exactly ascertained by a thorough examination of these structures, after death, in fatal cases of spinal fracture or dislocation. Indeed, it often is no easy matter to make such an examination, or even to get permission to make it, especially in private practice. But, as the membranes and substance of the brain are liable to become inflamed when they are wounded in any manner, so the membranes and substance of the spinal marrow, when similarly injured, are liable to become inflamed, (1) because the anatomical formation of these structures is identical in both; (2) because they extend continuously from one region to the other, the continuity of each structure being preserved intact throughout; and (3) because those inflammations which are essentially diffusive, spread readily from one region to the other, from the spinal canal to the cranial cavity, and *vice versa*. Cases of traumatic spinal meningitis and traumatic myelitis have been recorded much less frequently than cases of traumatic cerebral meningitis and traumatic cerebritis, it may be because post-mortem examinations have much less frequently been made in traumatic lesions of the spinal column than in traumatic lesions of the head.

The following account of traumatic spinal meningitis and traumatic myelitis is largely drawn up from the examples reported by our military surgeons during and since the late civil war, as well as from other reliable observations. In practice, it has been found that both diseases often occur together; but even then, either the one or the other usually predominates, and, therefore, the phenomena presented by individual cases will vary not only in accordance with the severity of the attack, but also in accordance with the disease which predominates, or the anatomical seat of the inflammatory lesion.

TRAUMATIC SPINAL MENINGITIS.—A considerable number of cases in which this lesion caused death have already been mentioned in the foregoing pages.

Symptoms.—This disorder, when acute, is often, but not always, ushered in by rigors or chilliness; pyrexia generally ensues, and the pulse rises as well as the body heat. There are pain more or less severe in the affected part of the spinal column (rachialgia), which is increased by motion; tenderness of the same part under pressure, with increase of temperature above that of the unaffected parts of the organism; and restlessness, sometimes great, with general cutaneous hyperæsthesia, the patient feeling "sore all over." Not unfrequently, pain with cutaneous hyperæsthesia exists in one or more of the extremities; occasionally, when paraplegia is present, the hyperæsthesia of the integuments occupies a band-like space, extending around the body just above the line of paralysis; in some rare instances, where the sensory filaments of the spinal nerves are greatly irritated by the inflammatory process in the adjacent membranes, the hyperæsthesia becomes very severe, and so distressing that words cannot describe the suffering; at the same time, the effects of this inflammatory irritation upon the motor filaments of the spinal nerves are manifested by stiffness and contraction of the posterior cervical and dorsal muscles, whereby the patient's head becomes drawn backward or recurved, so as to deeply indent the pillow; the patient may feel "stiff," as well as

"sore all over." When the motor filaments are greatly irritated in this manner, all the muscles supplied by these filaments are affected with tonic or tetanic spasms, and the case may be mistaken for one of tetanus; when the disease spreads to the cranial membranes, there is marked headache with other signs of cranial meningitis; as the case progresses from bad to worse, delirium followed by coma supervenes, and usually death soon ensues; but, occasionally, the tetanic spasms are so severe and extensive as to entirely stop the respiratory movements, thus causing death by sudden asphyxia, and then the mind may remain clear until the last moment. The examples of this disorder are, by their symptoms, clinically separable into three distinct groups: (1) the *foudroyant*, embracing those in which life is destroyed a few hours after the attack, as it were by a thunder-stroke; (2) the *tetanic*, embracing those in which tonic spasms of the muscles constitute the most striking part of the phenomena; and (3) the group embracing those in which *hyperæsthesia* is the predominating symptom.

It should be remarked, however, that the sign which is most characteristic of this disorder, is recurvation of the head and neck from tonic contraction (spasm) of the posterior cervical muscles.

The phenomena of each of the three clinical groups just mentioned will be exemplified by presenting, as briefly as may be consistent with clearness, some abstracts of appropriate cases.

The following abstract of a *foudroyant* case of traumatic spinal meningitis and myelitis is very instructive, as well as interesting:—

A cavalry soldier was wounded, October 14, 1868, in an affray, by a pistol-ball, which entered the right side of his neck, half an inch above, and somewhat external to the greater cornu of the hyoid bone, lodged, and was not extracted. On the 18th he entered the post hospital at Atlanta, Ga. There were complete motor and sensory paralysis of the lower extremities and the right arm, and partial paralysis of the left arm, with spasmodic movement when used; intercostal muscles paralyzed; respiration abdominal, and slow; pulse slow and regular; bowels partially, and bladder completely paralyzed; sensation lost throughout the abdominal region, but normal on the upper part of the chest and the face; intellect clear; patient complained of coldness of the surface, although the skin and extremities were hot to the touch. The track of the ball could not be ascertained, as the wound had nearly healed; but injury of the spinal cord was surmised.

During the *first* week in hospital, mucus constantly accumulated in the air-passages, threatening suffocation, which was averted by the use of stimulating expectorants. The bowels were relieved by injections and purgatives, and the bladder by the catheter. There was no perceptible improvement in the paralysis. A large bed-sore formed over the sacrum.

During the *second* week, there was partial recovery of motion in the right arm, but none of sensation. The patient could, by an effort, draw this arm across his breast. Oedema of the left leg appeared, and was treated by bandaging.

During the *third* week there was no improvement.

During the *fourth* week, on the suggestion of Dr. A. K. Smith, potassium iodide, and afterward tincture of ergot, were given with perceptible benefit. The mucus diminished in quantity, expectoration became easy, and the patient's appetite increased.

During the first part of the *fifth* week, the improvement was very encouraging. The respiration became more normal (that is, ceased to be diaphragmatic), the bowels acted readily, the appetite remained good, and the bed-sores looked healthy.

On November 20, the patient complained of stiff neck, headache [backache], and extreme coldness, and, toward night, had slight fever. On the 21st the fever had subsided, but he still complained of headache [backache] and coldness, and suppuration was diagnosticated. On the morning of the 22d he was comatose, with the left pupil dilated, and the right pupil contracted. A blister was applied to the nape of the neck, purgatives, etc., were given, but to no purpose; he died at 11.15 P. M. *Autopsy*, 15 hours after death.—The missile had passed from the point of entrance mentioned above, toward

the spinal column, crossing the carotid sheath externally, and just missing it. It appeared to have penetrated the spinal canal through the third intervertebral foramen, but it could not be found. The membranes of the cord and left hemisphere of the brain were extensively disorganized from inflammation. Plastic lymph, forming a continuous layer, was found effused on the inner surface of the theca vertebralis, throughout the entire length of the spinal cord. The subarachnoid space was distended with a pyoid serum, by which the cord was compressed and softened opposite the third and fourth cervical vertebræ. Here the theca vertebralis was ecchymosed and separated from the bone (by the missile). The layer of plastic exudation extended through the foramen magnum, and along the base of the brain as far forward as the optic commissure. In the anterior lobe of the left cerebral hemisphere, circumscribed softening was found, presenting the appearance of an abscess. The gray substance of this lobe was changed in color and consistence, in consequence of the inflammatory process; the medullary substance was injected; the lateral ventricles were marked by radiating bloodvessels; the corpora striata and optic thalami were injected.¹

This soldier died very suddenly from traumatic inflammation of the spinal and cranial meninges, the symptoms of which first appeared on November 20, death by coma following on the 22d. The symptoms were rigors, pyrexia, headache, backache, stiffness of the posterior cervical muscles, and coma, death resulting from compression of the brain as well as from compression of the spinal cord, effected by the products of a meningeal inflammation which extended over the whole length of the spinal cord, and over the base of the brain up to the optic commissure. It is probable that hyperæsthesia of the integuments and rachidian tenderness under pressure in the neck were also present at the outset. The anatomical changes wrought by meningeal inflammation are well described. There was a continuous layer of plastic lymph found on the inner surface of the dura mater, extending unbroken from the lower end of the spinal cord up to the optic commissure at the base of the brain. The meshes of the pia mater were also distended by a pyoid serum which lifted up the arachnoid. It is not improbable that this inflammatory attack was directly incited by the autumnal vicissitudes of atmospheric temperature, resulting from what is popularly called "catching cold."

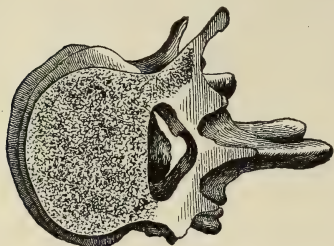
But the history of the first four weeks of this man's case is of equal, if not greater, interest to the thoughtful surgeon. The impact of the missile caused ecchymosis of the theca vertebralis, and separated it from the bone. It also bruised the spinal cord, from which lesion a very extensive paraplegia immediately resulted. Moreover, the bruising of the cord was followed by inflammation of the cord-substance, the symptoms of which were exaggerated reflex motion, particularly noted in the partially paralyzed left arm (for it exhibited spasmodic movements whenever he tried to use it), the sensation of cutaneous coldness without any apparent cause, the formation of a large gangrenous eschar over the sacrum, and the threat of death from suffocation. Next, there occurred a most interesting feature of the case, namely, the great benefit which was derived from potassium iodide and ergot. Under these remedies the myelitis rapidly subsided, the respiration ceased to be diaphragmatic, the appetite and digestion improved, the bowels, etc., acted readily, the bed-sores became clean and appeared healthy, and the case began to look quite encouraging; the existence of the nerve-lesions was proved, after death, by the softened state of the cord-substance which was found opposite the seat of the original injury.

The next abstract presents a brief record of a very instructive case in which *hyperæsthesia* was the most prominent symptom:—

¹ Circular No. 3, S. G. O., August 17, 1871, pp. 23, 24.

A cavalry soldier, aged 28, was accidentally wounded March 26, 1866, by a pistol-shot (conoidal, calibre, 36) which entered his loins near the posterior superior process

Fig. 880.



Showing a pistol-ball lodged in the spinal foramen (canal) of the fourth lumbar vertebra, and causing meningitis. (Spec. 683, Sect. I, A. M. M.)

of the right ilium, some two inches from the spine, passed inward, forward, and upward, struck the spinal column, and finally lodged in the spinal canal opposite the fourth lumbar vertebra (Fig. 880). He instantly fell to the ground; the lower limbs were paralyzed, and over the entire posterior part of the pelvis there was also complete loss of sensation. On the second day, he complained of much pain across the sacral region and in the thighs; could not change the position of the lower part of his body, and all attempts by others to move him gave great pain, especially across the lower part of his back; bowels torpid. He could micturate, but lacked expulsive power to do it readily. Afterward, he slowly improved. About the middle of April he was carried in an army-wagon, sixty miles, to the post-hospital at Austin, Texas, which he entered on April 18. He

then looked emaciated and anxious, and was much exhausted by his journey. He complained of pain, especially in the right side of the sacrum, and of severe pain in the posterior muscles of his legs, aggravated by pressure. He could not stand without support, and made no attempt to walk. When lying on his side, he was able to slowly flex and extend his legs, but could not separate them; bowels extremely torpid; urination frequent and very difficult; considerable thirst; but little appetite; upper extremities not affected. Under dry cupping of the sacral region, enemata and laxatives, tonics, nutrients, and alcoholic stimulants, he improved somewhat, but made no attempt to walk. Under the use of strychnia, early in May, his bowels moved spontaneously, and the ability to move his legs was somewhat increased. This medicine, however, was soon discontinued, because it readily exhibited an unduly stimulating action, characterized by the production of diminished sensibility from the haunches downward, with severe pain in the posterior muscles of the legs; appetite decreasing, and debility gradually increasing. During the second week in May and forepart of the third, the patient's general tone diminished greatly; sensibility became lost almost entirely below the knees, but limited motor power still remained. The power to urinate was nearly lost; urine passed in drops, with continued painful desire to pass more (vesical hyperæsthesia); introducing the catheter gave temporary relief, but he could not retain the instrument longer than a few minutes [in consequence of the urethral hyperæsthesia]. From this symptom, beladonna (gr. $\frac{1}{4}$) would, for a considerable period, give most decided relief. The patient lay chiefly on his back, with the knees drawn up; stools passed involuntarily. The pain in the legs and in the sacral region was increased; wet cups were applied over the lower part of the spine, daily, for four days, but without any benefit whatever; he was catheterized twice daily, and this was continued until the end. On May 24, he rejected all food. On the 25th, there was active delirium. On the 27th, the delirium still continued; pulse 120; respiration 40, and performed almost entirely by the diaphragm; no sensation in legs, excepting under hard pressure, but he kept them flexed upon the thighs, and the thighs upon the pelvis; complained of intense pain in the back part of the pelvis, abdomen, and thorax, extending along the spine upward, making it difficult to rest his neck upon the pillow; he described the pain as that of lying upon hot embers; he continued to cry out in pain until a few moments before death, which occurred on the following morning (May 28). *Autopsy*, twenty-one hours after death.—The missile had grazed the right transverse process of the fifth lumbar vertebra, imbedding some particles of lead therein; then, glancing upward, had struck the spinous process of the third lumbar vertebra (its lower border), and had been deflected through the laminæ into the spinal canal. Here, it had been deflected downward by the elastic action of the ligamenta subflava to which the upper border of the broken laminæ remained attached, and had lodged (point downward) within the spinal foramen of the fourth lumbar vertebra. The missile rested within the leash of nerves forming the cauda equina, near the left angle of the spinal foramen (canal), its point reaching downward to the lower border of the fourth

lumbar vertebra. The spinal membranes surrounding the point of the missile were lacerated, injected, and of light venous color. The nerve-tissue within the spinal membranes was also injured; it was reduced nearly to a pulaceous consistence; white softening. The fourth and part of the third lumbar vertebra, with the missile attached, was contributed to the Army Medical Museum. This specimen is represented by the accompanying wood-cut (Fig. 880).¹

The intense agony which was engendered by the hyperæsthesia in this case is something too horrible to be contemplated without emotions of pity.

It is worthy of remark that strychnia did harm to this patient, and that its use was suspended for this cause. It is also worthy of remark that the vesical and urethral hyperæsthesia was notably lessened by giving belladonna, and that the application of dry cups was apparently useful on another occasion.

The next example occurred in the Crimean war. Intense *hyperæsthesia* appeared, and *foudroyant* symptoms. Death from coma (that is, from compression of the brain and spinal cord) resulted in five days.

Private S. L., aged 21, was wounded in the trenches, August 23, 1855. A Minié ball passed through his right cheek, fractured the right alveolar processes and ascending ramus of the lower jaw, with comminution, and lodged near the base of the skull. There was not much hemorrhage. The ball could not be discovered, and every attempt to find it caused very acute agony. There was no paralysis. But deglutition was difficult, and every movement of his neck aroused intense pain, so much so as to cause him to scream violently. Delirium, stertor, and coma set in; death ensued on the 28th, five days after the casualty. *Necroscopy* showed both jaws to be fractured, and the lower comminuted. The missile had lodged just below the basilar process, having broken off and almost detached a large piece of the atlas, and thus uncovered the spinal membranes. They did not appear to have been injured primarily; "but they, as well as the membranes of the brain, showed marks of acute inflammation having been set up."²

On the same page, Staff-Surgeon T. P. Matthew, the surgical historiographer of the Crimean War, remarks: "Even where the spinal cord, apparently, was not primarily injured, inflammation of it or its membranes was sometimes set up, and quickly proved fatal."

The following example of traumatic spinal meningitis and myelitis was characterized by the occurrence of *tetanic* spasms of the muscles in the extremities:—

On the first of August, says Stromeyer, I extracted a bullet, which had entered on the 6th of July, between the laminae of the third and fourth lumbar vertebrae, and there had become fixed. At first there were no severe symptoms; suddenly there occurred violent pains, with cramp in the extremities having similarity to tetanus, and accompanied by delirium. The operation was easily performed by the help of an elevator, after dilating the outer wound. On removing the bullet, a finger could be put into the spinal canal. The patient sank rapidly, and the *autopsy* showed inflammation of the spinal cord and its membranes.³

Tetanic spasms of the muscles were likewise observed in the next instance, which occurred in our civil war:—

An artillery soldier, aged 28, was wounded at Gettysburg, July 1, 1863, by a conoidal ball, which entered below the spine of the left scapula, struck the spinous process of the eighth dorsal vertebra, fractured it, but without displacement, and lodged in the angle between the spinous and transverse processes. He walked to the field hospital without assistance, and was able to move about and help himself until the 6th, when tonic spasms of the abdominal muscles and diaphragm set in. They steadily increased in severity; anæsthetics were administered, and the urine was drawn off by

¹ Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 448.

² Medical and Surgical History of the British Army in the Crimean War, vol. ii. p. 337.

³ Op. cit., p. 38.

a catheter. On the evening of the 7th, he fell into a sleep; but, upon awakening, the spasms returned and continued until 11 P. M., when death occurred.¹ Though the track of the missile was traced in this case, and its place of lodgment discovered by a post-mortem examination, it does not appear that the spinal canal was laid open, and that the spinal meninges and cord were submitted to inspection. Had such an examination been made, the evidences of traumatic spinal meningitis would doubtless have been revealed; for it should be observed that the tetanic spasm first appeared in the muscles (of the abdomen) that were supplied by spinal nerves (the seventh and eighth dorsal) which issued from the spinal column at the place of injury (the eighth dorsal vertebra), and consequently from the focus of traumatic inflammation, whereas true tetanus usually begins with trismus or lock-jaw. There is, then, little room for doubt that the tetanic spasms of the abdominal muscles, etc., which appeared in this case, were merely symptoms or phenomena that resulted from the inflammatory lesions of the spinal membranes and spinal cord.

Moreover, *tetanic* spasms characterized an example presented on page 376, together with a wood-cut to illustrate it, that bears a strong resemblance to Stromeier's case as briefly related above. In both, a small-arm missile struck the spinal column, and became impacted between the laminæ of two lumbar vertebræ. In both instances, severe pain in the spine and *tetanic* spasms in the muscles of the extremities ensued. In both instances the missiles were extracted, and both patients died. The autopsy of Stromeier's patient revealed traumatic inflammation of the spinal membranes and cord. But the autopsy of the other patient does not appear to have been carried far enough to expose the spinal membranes and spinal cord to view. Nevertheless, the symptoms which characterized this case, *e. g.*, the intense rachidian pain, the extreme degree of restlessness or general hyperæsthesia, and the tetanic spasms, constitute a group of symptoms often seen in cases of epidemic cerebro-spinal meningitis when the spinal symptoms predominate; and, without doubt, these symptoms arose in this instance also from an acute inflammation of the spinal membranes, but having a traumatic, instead of an epidemic origin, just as they did in Stromeier's case.

Epileptiform convulsions, as well as tetanic spasms, are sometimes observed in cases of traumatic spinal meningitis. Charles Bell² reports an example in which a subluxation of the last cervical upon the first dorsal vertebra was followed, on the eighth day, by general convulsive movements, accompanied by signs of inflammation of the spinal membranes. The patient died twelve days afterward of exhaustion, not having been completely paraplegic at any time. The *autopsy* showed a little subarachnoid effusion of serum in the cranium, and an abundant deposit of pus within the theca vertebralis, lying between it and the spinal cord. This case has already been mentioned (page 332).

Pathological Anatomy of Traumatic Spinal Meningitis.—The spinal membranes, like the cranial, are not much disposed when injured to exhibit inflammatory changes of a destructive character. Still, when their vulnerability is attended or followed by influences adverse to healing, they, like the cranial membranes, are liable to take on inflammatory action which may cause death. Having thoroughly discussed the symptoms of traumatic spinal meningitis, it is next in order to consider the structural lesions which it engenders. They consist in the exudation of serum, the formation of plastic lymph and purulent matter, and the perforation, etc., of the membranes themselves by ulceration. The following abstract and wood-cut (Fig. 881) will serve to illustrate at least some of these lesions.

¹ Medical and Surgical History of the War of the Rebellion, First Surgical Vol., p. 452.

² Surgical Observations, p. 145.

A soldier, aged 37, received a gunshot wound of the back, at the Wilderness, May 6, 1864; the ball entered over the transverse process of a dorsal vertebra, and lodged in the bone. He was sent to Washington; and, on the next day, he was admitted to Mount Pleasant Hospital. On the 15th, he was transferred to Jarvis Hospital, Baltimore, where he died on July 20, seventy-five days after the casualty, from spinal meningitis. *Necroscopy*.—It was found that the ball had struck the body, and fractured the transverse process, of a dorsal vertebra. The injured bone was necrosed. The spinal membranes showed ulceration and unequivocal marks of intense inflammation, for two inches above and below the fracture. The spinal cord, opposite, was partially disorganized. The inflammatory lesions of the meninges are represented in the adjoining wood-cut (Fig. 881).¹

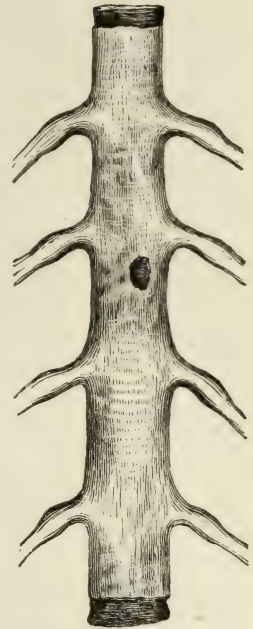
It does not appear that the spinal cord and membranes, in this man's case, received any direct injury from the blow struck by the missile upon his spinal column. Subsequently, however, the vitality of the bruised vertebra was destroyed by necrosis, and the inflammatory process spread therefrom to the contiguous membranes and cord, when the traumatic spinal meningitis, thus excited, caused his death seventy-five days after infliction of the wound.

The inflammatory process, when it is excited in the spinal membranes by traumatic causes, may be either diffuse or circumscribed in character. In several instances, related above, it was very diffuse, and not only involved the entire extent almost of the spinal membranes, but passed upward through the foramen magnum and attacked those of the cranium. In the last example, however, it was not diffuse, but confined to a space extending two inches above and below the place of injury. In the next case the meningeal inflammation was also circumscribed and restricted to comparatively narrow limits:—

Capt. Thomas H., 67th Regt. Indiana Vols., was wounded by a pistol-ball in the back, November 3, 1863, and entered a general hospital on the 9th. There was partial paralysis of the *left* thigh and extremity. The missile had entered about four inches to the *right* of the fourth dorsal vertebra, but its course could not be traced. The tract of the spinal column, both above and below the wound, was equally sensitive. The paralysis, in the first week, invaded the right leg, the bladder, and the rectum; and, by the end of the third week, sensibility and voluntary motion had disappeared (that is, there was complete paraplegia) in all parts below the wound. The only noticeable instance of excito-motor action which remained was the peculiarity that tickling the glans penis produced a partial evacuation of the bladder; and this feature continued until the patient's death, which resulted from acute pneumonia on December 19. *Necroscopy* showed that the ball had passed downward and inward, slightly wounding the costal pleura; had fractured the right transverse process of the seventh dorsal vertebra; and had lodged in the body thereof, producing a slight exfoliation from the inner side of the body into the spinal canal, which had caused inflammation of the spinal membranes and cord. Pus was found in the theca, that is, in the spinal pia mater. The right lung was far advanced in suppuration.²

This case is strictly analogous to those instances of traumatic meningitis and cerebritis which arise from exfoliations from the inner table of the skull,

Fig. 881.



Showing the effects of traumatic spinal meningitis and myelitis, in the dorsal region. The membranes have been perforated by ulceration, and exhibit other inflammatory changes; cord partially disorganized. (Spec. 3190, Sect. I, A. M. M.)

¹ Med. and Surg. Hist. of the War of the Rebellion, First Surg. Vol., p. 439.

² *Ibid.*, p. 438.

in consequence of cranial injury, and which produce subdural or intrameningeal abscesses, attended by corresponding palsies of the cerebral functions. In this officer's case, the pressure exerted by the products of the meningeal inflammation (purulent matter and serum) upon the spinal cord, as well as the inflammatory changes which occurred in the cord-substance itself, caused complete paralysis of all the parts of his body which were situated below the spinal lesion.

A few words should also be said concerning the *pathological histology* of traumatic spinal meningitis. This disorder usually consists of acute hyperæmia and suppurative inflammation of the pia mater. There is a tolerably well-marked congestion of all the vessels in the pia mater, together with purulent infiltration of the subarachnoid lymphatic spaces. The most striking point in connection with it is the strict way in which the purulent formation is limited to the parenchyma of the pia mater; it never transgresses (when diffuse) the arachnoid lamella which forms its outer boundary. In the first *foudroyant* example related above, the meshes of the pia mater were seen to be distended by purulent serum which lifted up the arachnoid. The comparison of the arachnoid to a serous sac, formerly so popular, has ceased to be entertainable ever since Luschka's investigations proved that the so-called parietal layer of the arachnoid was merely the epithelium of the dura mater. The very striking deviation from the superficial character of serous inflammations in general, just mentioned, completes the demonstration that the arachnoid is not a serous membrane in the same sense as the pleura or the pericardium. "It seems to me," says Rindfleisch, "as though this deviation were simply due to the presence of very distensible spaces immediately around the vessels. Here, if any where, we may apply Cohnheim's theory of inflammatory exudation. Even the naked eye can show us that the pus everywhere originates along the course of the vessels. Like a double-streak of a yellowish-white color, narrow at first and growing steadily wider, the pus follows the edges of the vessels, especially of the large and small venous trunks. The longer the process lasts, the nearer do the purulent streaks accompanying the vessels approach one another, till they finally coalesce; the pia mater swells up as a whole; it often acquires a peculiar stiffness, owing to the stretching of its fibrous bands, perhaps also to the coagulation of some lymphatic constituents of the exudation."¹ It may then be stripped off from the compressed and bloodless, rarely softened, surface of the cord, together with the prolongations which it sends into the sulci, forming a solid mould of the rachidian irregularities. The morbid process generally begins with hyperæmia (active congestion) of all the inter-meningeal vessels at the place of injury, followed by the appearance of serum and flakes of lymph; and it terminates, as just stated, in subarachnoid suppuration.

Treatment.—Traumatic spinal meningitis, whether diffuse or circumscribed, is an exceedingly dangerous disorder; and, to treat it with success, it is indispensable that vigorous measures should be promptly employed. The preventive measures (*prophylaxis*) consist in removing all foreign bodies from gunshot wounds of the spine, and applying antiseptic dressings; in reducing simple as well as compound dislocations and fractures of the vertebræ, thereby lessening the meningeal irritation; in maintaining afterward absolute quietude of all the injured parts; and in promptly abating any inflammation which may arise in the circumjacent structures.

Meningeal congestion should be combated by administering ergot in large doses at short intervals (from 30 to 60 minims of the fluid extract every four

¹ Manual of Pathological Histology, vol. ii. p. 309. New Sydenham Society's translation.

hours until the indication is fulfilled), and by giving opium or morphia in such doses and at such intervals as will suppress the rachidian pain.

The inflammatory process is to be combated by exhibiting one or two purgative doses of calomel at the outset, by abstracting blood locally with leeches or cups, by applying cold to the overheated back, and by administering saline drinks of a cooling, laxative, and diuretic nature. At a later stage, potassium iodide in full doses, and counter-irritation by vesicants or by the actual cautery should be employed. The remedy, however, which is most efficacious to remove meningeal congestion is ergot, provided it be given in sufficiently large doses; while that which is most effectual to prevent the exudation of serum and the formation of plastic lymph (and thus to save the spinal cord from undue pressure), is opium, or morphia, also given in adequate doses.

No attempt should be made to relax the tetanic spasms by administering chloroform or any other anæsthetic; such medication did no good whatever in two cases which are mentioned above, and it probably hastened the end in each. But morphia combined with the bromides of calcium, sodium, potassium, or ammonium, and chloral hydrate, may be used for this purpose.

In treating the paralysis attending the chronic forms of the disease, the bichloride of mercury, in doses of gr. $\frac{1}{16}$ every eight hours, often does good. Strychnia is not admissible, and it clearly did harm in one case above related.

TRAUMATIC MYELITIS.—As cerebritis is true inflammation of the *brain-substance*, so myelitis is true inflammation of the *cord-substance*, and as cerebritis presents a marked contrast to cerebral meningitis (or what is popularly known as “inflammation of the brain”) in respect to extent, acuity, and phenomena, so true inflammation of the cord-substance differs widely in the same particulars from spinal meningitis (or what is sometimes known as “inflammation of the spinal cord”), which has just been described.

Both cerebritis and myelitis are always *caused* by a wound or an injury in the widest sense of the term—that is, by some local irritation of extra-cerebral or extra-rachidian origin. The skull or the spinal column may have been struck or concussed; it may have been penetrated by a cut, a stab, or a fracture, which has directly damaged the brain-substance or the cord-substance; or a focus of inflammation and suppuration, originating in the neighborhood of the brain or the spinal cord, may have been propagated to its tissues at the point of contact; or, finally, the plugging of a vessel by an embolon, or a thrombus, or the rupture of its coats from atheromatous disease, etc., may have caused a circumscribed, punctiform hemorrhage, followed by inflammation as a secondary consequence.

In myelitis, and in cerebritis, the behavior of the parenchyma proper of the spinal cord and brain is the main point to be attended to; this is usually said to undergo purulent liquefaction; and the statement is so far true that a deposit of pus is usually found to occupy the place of the rachidian or the cerebral substance.

“The phenomena of acute myelitis leading to abscess are exactly similar to those of encephalitis [or cerebritis]. The form of the affected part varies with the [nature of the] injury. Fractures of the spine usually crush the cord; inflammation and suppuration take place around the crushed part, and isolate it from the healthy tissue.”¹ Many examples of traumatic myelitis have already been mentioned in this article.

Symptoms.—The acute form of the disease is often ushered in with a dis-

¹ Rindfleisch, op. cit., vol. ii. pp. 324-330.

tinct chill; pyrexia follows, with thirst and increased frequency of pulse, and the body temperature may rise to 103° Fahr. The affected part is generally the seat of a dull pain or ache (quite distinct, however, from the intense pain of meningitis), which is increased by bending and by percussing the diseased part, and by applying a hot sponge over it. The functions of the spinal cord are immediately disturbed, and notable derangements of the cutaneous sensibility at once ensue. They often take the form of "pins and needles," of a sensation as if water were trickling over the cutaneous surface, as if the limbs were asleep, or as if the cutaneous surface were very cold, while in reality it is very hot, and *vice versa*. It will be remembered that coldness of the surface without any apparent cause was complained of in the first *foudroyant* case of spinal meningitis above related. But anæsthesia is the general condition of the skin that is most common in this disease. It is, however, attended not unfrequently by cutaneous pain or hyperæsthesia; indeed, spontaneous and severe pains are often felt in the skin, when the cutaneous sensibility is already much impaired. Complete analgesia soon follows.

The voluntary motility is destroyed at an early period in this disease. At first the reflex excitability may be exaggerated, but it likewise soon disappears. Then the sphincter ani and sphincter vesicæ entirely cease to act, and the feces and urine flow out into the bed without any restraint whatever. The urine becomes alkaline, and oftentimes is thick with mucus.¹ Simultaneously, sacral eschars, or so-called acute bed-sores, are very liable to be formed. These eschars are due less to the patient's position than to the lesion of the spinal cord. In twenty-four hours these bed-sores sometimes appear, and in such cases the febrile movement caused by the myelitis is often mistakenly ascribed to the eschars themselves.

In the *subacute* and *circumscribed* forms of the disease, the aberrations of sensibility are less strongly marked, and they succeed each other less rapidly on account of the slower progress or the more restricted range of the morbid process. The sensation of a band drawn tightly around the body is generally, but not always, present in such cases, and its seat marks the upper limit of the rachidian inflammation. The destruction of voluntary motility and of reflex excitability usually travels upward, *pari passu*, with that of sensibility.

The inflammatory process in traumatic myelitis generally exhibits a remarkable tendency to spread upward in the rachidian substance. This peculiarity was long ago specially noted by Dupuytren, in cases where inflammation of the cord had arisen from dislocation or fracture of the spine. The most frequent mode in which traumatic myelitis destroys life is by paralyzing the respiratory muscles in consequence of its upward spread, and thus causing fatal asphyxia. The following example illustrates this point, as well as several others in the natural history of the disease:—

A cavalry soldier at Fort Gibson, Cherokee Nation, received a shot-wound in the neck, in a brawl, on November 19, 1868, and was taken into hospital shortly afterward. There was complete paralysis of both upper extremities; respiration gasping and frequent; pulse about 100, of fair volume and strength; mind clear; he complained of some pain in the hands. The missile had penetrated the neck, on its left side, at the anterior

¹ Dr. C. B. Radcliffe, however, has recorded a case (Lancet, December 3, 1864) in which the urine remained *acid* throughout. The myelitis was acute and very extensive, and in ten or twelve days death ensued. There were retention of urine and marked priapism. The motor and sensory paralysis extended up to a line drawn round the body four inches below the ensiform cartilage; reflex movements absent. *Autopsy*.—Spinal membranes, normal; substance of cord, yellowish-red in color and softened to the consistence of cream, from its brachial enlargement to its inferior extremity; it here consisted of the débris of its normal structure mixed with blood-corpuscles, exudation granules, and some pus-corpuscles.

border of the trapezius muscle, and about two inches below the mastoid process; passed downward and to the right; fractured one or more of the vertebræ; and lodged beyond the reach of the bullet-probe. A few loose fragments of bone were removed. He was placed on a water-bed. Anodynes were given to procure sleep and relieve pain. The bladder was relieved by the catheter. The paralysis of the abdominal muscles allowed gases to collect in the intestines to such an extent as greatly to augment the pre-existing difficulty of breathing. Vent was given to these gases, from time to time, by inserting an elastic tube, *per anum*, and compressing the belly externally. The paralysis from day to day became more profound; the respiration more difficult; asphyxia slowly appeared, with delirium followed by coma, and on the 28th death ensued, about nine days after the casualty. The *autopsy* revealed (1) fracture of the spinous process of the last cervical vertebra; (2) fracture of the laminae of the first dorsal vertebra at the point where they unite to form the spinous process; this fracture opened the spinal canal and ruptured the theca vertebralis; (3) several small fragments of bone, embedded in the substance of the spinal cord, which was softened and bathed in pus. The bullet had also fractured the first rib with the coracoid process of the scapula, and had lodged in the right axilla, where it was found. The lungs were deeply congested, as was the mucous coat of the bronchi; and the bronchi themselves were filled with a tenacious mucus.¹

The injury of the spinal cord in this case was followed by suppurative inflammation of its substance, which not only involved the whole thickness of the cord, but spread upward also. Simultaneously the paralysis became more profound, and rose to higher points, from day to day, until the man breathed by the diaphragm alone. Then the occurrence of tympanites greatly increased the dyspnoea by opposing the descent of the diaphragm; tenacious mucus formed in the air passages, and accumulated therein, because there was no power to expel it by coughing; mucous râles (bronchial) soon supervened, and death from suffocation ensued, ere the disintegrating process had ascended the cord high enough to paralyze the phrenic nerves. This man died of ascending myelitis in nine days. But, on page 343, I have presented the case of another soldier who died of ascending myelitis in about forty-eight hours after sustaining simple fracture of the fourth cervical vertebra, in consequence of falling from a second story. On another page, I have mentioned the case of a man, aged 40, who died of ascending myelitis on the eleventh day after sustaining simple fracture and dislocation of the eleventh dorsal vertebra, with contusion of the cord. I have likewise referred to many other cases of spinal injury, in which ascending myelitis supervened with fatal effect, as was shown by necroscopy.

In the next example, the patient died of hæmoptysis before the inflammatory process in the spinal cord had reached the stage of suppuration:—

A cavalryman, aged 35, entered a general hospital, October 28, 1864, for a wound from a pistol-shot which had penetrated to the left side of the spine, and had fractured the twelfth dorsal vertebra. All below a line drawn from the wound to the pubis was paralytic. There was much depression; pulse about 130; much pain over abdomen and right side; constipation; incontinence of urine from overflow of bladder. A catheter was introduced and three pints of very thick, dark-colored urine were withdrawn. Stimulants, tonics, and a cathartic were given, with an anodyne at night. The patient improved and did well until November 15, when a bad cough set in. He died suddenly on the 18th from hæmoptysis. *Necroscopy*.—The spinal canal was laid open posteriorly from the second dorsal vertebra to the sacrum. Upon removing the spinal cord, the theca was found congested and firmly adherent to the vertebræ. The substance of the cord looked very red. The ball had passed between the arches of the twelfth dorsal and first lumbar vertebræ, and then through the body of the twelfth dorsal, outside of the spinal meninges; but its track could not be further traced. The right pleural cavity

¹ Circular No. 3, S. G. O., August, 17, 1871, pp. 21, 22.

contained three pints of dark, bloody, stinking fluid. The muscular tissue in the lumbar region was very dark and softened, but contained no abscesses nor infiltrated pus.¹ Death occurred three weeks after the infliction of the wound.

The membranes and substance of the spinal cord, in this case, exhibited the signs of convalescence from inflammation, and that process must have run pretty high at one time, for the theca vertebralis had become strongly adherent to the spinal column. The spinal membranes were still congested, and the cord-substance looked very red, when exposed to view at the autopsy.

Pathological Anatomy.—This reddened hue of the rachidian parenchyma is accounted for by the peculiar manner in which the vascular apparatus is involved. The intense hyperæmia which ushers in the morbid changes invariably gives rise to a large number of minute ecchymoses; these, of course, are equally numerous when the hemorrhage is the primary and the inflammation the secondary phenomenon. Should the affected part undergo softening and purulent liquefaction, the extravasated blood mingles with the pulp, and imparts to it a more or less intensely red color. Hence, the term *red softening* is generally applied to parts affected by encephalitis (cerebritis), or by myelitis; but this term is equally applicable to other cases in which similar effects are produced by very different causes. The presence of pus is characteristic of the inflammatory form of red softening; so, too, is the presence of an areola, from one to two lines in width, in which the parenchyma is studded with numerous bloody points, and swollen by a commencing purulent infiltration. (Rindfleisch.) But purulent softening had not yet appeared in the example just related; or, rather, the hyperæmia of the rachidian parenchyma, which was very intense and accompanied by a great multitude of minute extravasations of blood, seems to have been passing away, that is, undergoing resolution or cure, the intensely red hue arising therefrom alone remaining. I have dwelt somewhat upon this case, because it affords sure ground for the hope of obtaining a cure by timely medication in analogous cases of traumatic inflammation of the membranes and substance of the spinal cord.

But when, on the other hand, resolution of acute hyperæmia of the cord does not occur, either spontaneously or in consequence of treatment, purulent infiltration of the reddened tissue will ensue, and purulent matter will take the place of the rachidian substance. Concerning the manner in which the liquefaction occurs, no unquestionable theory can be advanced in the present anarchical state of our doctrines concerning suppuration. "We can but express suppositions, keeping a firm hold on individual facts of unquestioned certainty to serve as guides. Among these I include," Rindfleisch justly observes, "the passive behavior of the nervous elements in the suppurative process, and the intense activity of the vascular system in every stage of the disease. The nerve-fibres within the affected area are partly suspended in the pus as disconnected fragments, partly protruded from the walls of the cavity in a state of advancing maceration and decay. I have not been able to detect any traces either of fatty or of granular degeneration in them; drops of myelin separate from their surface; the axis-cylinders grow thinner by degrees, and finally disappear. The ganglion-cells of the affected part become darkly granular, and break up into splinters; I have often recognized well-marked fragments of them in the pulp."² From what source comes the purulent matter in such cases? The same indefatigable observer remarks:—"My own investigations have taught me that the pus first collects around those vessels from which extravasation [of blood] has occurred. In trans-

¹ Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 441.

² Op. cit., vol ii. p. 325.

verse sections of the encephalitic foci (red softening), hardened in preservative fluids, we find these vessels girdled by a relatively wide areola of pus-cells; and by dint of careful management, we may even pull vessels coated with pus—furnished with regular sheaths of pus-corpuscles—out of the recent specimen. Finally, we may also see in the transverse sections that the pus has actually pushed the extravasated, but still fluid, blood away from the vessels, the blood-corpuscles forming a ring around the pus, instead of a globular drop. This would lead us to infer that the pus was generated by the adventitia, or furnished by the emigration of leucocytes. Nevertheless, I am loth to refuse the power of generating pus to the neuroglia; I am quite sure that it is capable of producing corpuscular elements (solitary tubercles, gliomata); and, although I regard the results of my inquiries, just given, as trustworthy so far as they go, yet I do not consider them exhaustive.”¹ The purulent matter, then, in such cases, (1) arises from the emigration of leucocytes; (2) is generated by the adventitia; and (3) is probably produced also by the neuroglia; but, whatever be its origin, it destroys and takes the place of the inflamed substance of the cord. Thus suppurative inflammation of its substance may demolish the structure of the spinal cord, not only through and through, but upward as well as downward for a considerable distance in its continuity. Thus come to pass the disorganized and liquefied conditions of the spinal cord revealed by necroscopy in cases of vertebral fracture or dislocation, where death has occurred some days or weeks after the accident, many examples of which have been mentioned in the foregoing pages.

To emphasize this important point, a few brief abstracts will here be added:—

(1) Zambaco² mentions the case of a man having fracture and luxation of the third dorsal vertebra. The compression of the spinal cord was not constant; it could be relieved by pressure. However, death ensued eighteen days after the injury, through the lungs; that is, from asphyxia. (Ashhurst.) No doubt, the injury of the cord in this case caused ascending myelitis which disorganized the cord in the upper dorsal and lower cervical regions, paralyzed the respiratory nerves and muscles thereby, and thus completely arrested the respiratory movements.

(2) Luke³ reports the case of a man who had fracture of the seventh dorsal vertebra. The displacement was corrected by making extension, and reduction was accompanied by an audible sound. Death from erysipelas supervened seven days after the accident. On *autopsy*, the spinal cord was found to be softened and disorganized, and to contain purulent matter. (Ashhurst.)

(3) Dupuytren⁴ mentions the case of a man injured by jumping from a third story. There was deformity of the spinal column in the lumbar region, with great mobility; paralysis, at first partial, but afterwards complete; and bed-sores. Death resulted. The *autopsy* revealed fracture of the second dorsal vertebra; the spinal cord was liquefied; and a purulent cyst was found by the tenth dorsal vertebra. (Ashhurst.)

(4) Adams⁵ relates the case of a woman, aged 28, who fell ten feet, striking the head. “Grating in the neck” was felt; there was a protuberance in the pharynx and a depression in the back of the neck; paralysis; pain; dyspnoea; retention of urine; insomnia; involuntary evacuation of the bowels; bed-sores; and convulsions. In twelve days death ensued. The *autopsy* revealed dislocation of the fifth from the sixth cervical vertebra; also fracture of the sixth dorsal vertebra. Opposite the latter point the spinal cord was divided, and above it the cord was softened. (Ashhurst.) Here again was shown the remarkable propensity to travel upward, which characterizes traumatic myelitis.

¹ Ibid., p. 326.

³ Lancet, 1850.

⁵ Dublin Med. Journal, vol. vi.

² Rec. des Trav. de la Soc. Méd. d’Obs., t. i.

⁴ Diseases and Injuries of Bones.

Moreover, in occasional, perhaps in frequent instances of traumatic myelitis, the inflammatory process does not involve the whole thickness of the cord; it may be restricted to the central gray matter; and, possibly, to one of the columns. An instance in point is given by Anstie:—¹

A woman, aged 38, fell thirty feet from a window, and came under Mr. Holt's care. There was a scalp wound, with "concussion;" paralysis and delirium. In eight days death supervened. The *autopsy* showed fractures of the sixth cervical vertebra and skull; red softening of the central gray matter of the cord; antero-lateral columns healthy. (Ashhurst.)

Another instance in point is given by Genest:—²

A woman, aged 40, received a blow on her back. Six weeks afterwards she felt pain starting from the right foot. Gradually the pain extended to various parts of the limb; and, after a month, it was accompanied by spasmodic contractions, and by diminished voluntary motion. She walked with great difficulty, even with the help of a stick. There was no alteration in the temperature of this limb. The convulsions extended to the other limbs and to the head, and the patient died. *Autopsy*.—Brain normal; cerebellum a little softened; no meningitis; spinal cord healthy, excepting at the swelling for the lower limbs, which, for an extent of eighteen lines and a depth of one line, on its posterior aspect, was softened, and looked like cream, somewhat rose-colored. The softening in this case was obviously inflammatory, and was restricted to the posterior columns. This circumstance is also instructive as well as interesting, because the morbid action was engendered by concussion (contusion) of the cord substance.

To briefly enumerate the *morbid appearances* which result from traumatic myelitis: they are (1) red softening; (2) purulent infiltration of the reddened and softened rachidian substance; (3) collections of purulent matter (abscesses) surrounded by areolæ of red softening, one or two lines thick, in the rachidian substance; (4) more or less complete liquefaction of the cord, but without well-defined margins. The morbid appearances usually extend through the whole thickness of the cord, and some considerable distance in a longitudinal direction, but mostly upward; occasionally, however, they are restricted to the central gray matter, or to the columns.

Etiology.—Traumatic inflammation of the spinal cord may arise from any wound which penetrates the spinal canal. It is often caused by simple fractures and dislocations of the spinal column, as well as by those that are compound. It is not unfrequently produced by concussions of the spinal cord, especially those that are attended by ecchymosis of the cord-substance; in such cases, the inflammatory process is apt to be subacute and to pursue a chronic course.

Dr. Nairne,³ however, has recorded an acute case occurring in a lad, aged 17, in whom it was caused by severe jolting in a cart. Next day he was unable to walk, from paralysis; he rapidly grew worse; and, after ten days, he died. On *autopsy*, the spinal veins were found to be greatly congested; and a portion of the spinal marrow opposite the third and fourth dorsal vertebræ, at least one inch in length, was thoroughly disorganized and reduced to a semi-fluid state.

Occasionally, traumatic myelitis results from violent strains of the spinal column, although the bones and ligaments are apparently uninjured.

Sir W. Gull⁴ relates the case of a man, aged 25, employed as a laborer in the commercial dock, who felt a sudden pain in the back after lifting some deals, on November 22. He walked to his home (about a mile and a half); was apparently well on the

¹ Trans. Lond. Path. Society, vol. x.

² Brown-Séquard, op. cit., p. 72; quoted from Gazette Médicale de Paris, 1831, p. 34.

³ Medico-Chirurgical Transactions, vol. xxxiv. p. 37.

⁴ Guy's Hospital Reports, 1858, pp. 189, 190.

following day. Next morning (November 24), on waking, the legs were paralyzed. On the 26th, he entered the hospital. There was complete paraplegia, a bed-sore had already begun to form over the sacrum, and ammoniacal urine dribbled from the bladder. He died exhausted, on January 2, forty-one days after the strain.

Autopsy.—A large bed-sore exposed the sacrum in its whole length. The bones and ligaments of the spine exhibited no trace of injury. The cord was softened, opposite the fifth and sixth dorsal vertebræ, through all its columns, into a thick, greenish, mucopuriform fluid, with a brown tinge. Lumbar and cervical portions of the cord normal. Commencing suppuration in the cortical substance of the kidneys. Mucous membrane of the pelves greenish, with patches of greenish fibrinous exudation. Mucous membrane of the ureters and bladder in the same condition; the bladder contained a quantity of muco-purulent fluid. The microscope showed the softened part of the cord to consist of disintegrated nerve-tissue, with a few irregular collections of granules.

Prognosis.—The outlook in cases of traumatic myelitis is always gloomy. From inflammatory disintegration of the spinal cord, gangrenous bed-sores often arise; and they prove fatal, not unfrequently, by inducing septicæmia or pyæmia, as happened in the following instance:—

A soldier was wounded at Antietam, September 17, 1862, in the lumbar spine, and lay on the field until the 20th, when he was taken to general hospital. At that time he could walk, but paralysis soon supervened. Retention of urine lasted two days; no difficulty afterward; no derangement of the alimentary canal; pulse small and weak; face flushed. The patient suffered greatly from bed-sores. On October 6 he suffered great pain in the legs; they were without feeling, but warm. On the 10th, profuse sweats occurred; he sank rapidly, and died on the 11th, apparently of septicæmia arising from the bed-sores. A conoidal ball was found to have passed through the spinal column and cauda equina at the third lumbar vertebra, and to have lodged at the left intervertebral foramen; condition of cord and membranes not reported.¹

Again, traumatic myelitis may destroy life by causing vesical and renal inflammation, as well as an alkaline state of the urine. But the discussion of this point is reserved for the section on Disorders of the Urinary Organs arising from Lesions of the Spinal Cord.

Most frequently, however, traumatic myelitis ends in death by ascending the spinal cord until it involves the origins of the spinal nerves upon which the respiratory movements depend, when paralysis of the respiratory muscles and death from asphyxia (apnoea) ensue. Stromeyer mentions a case in which the posterior parts of the fifth and sixth cervical vertebræ were torn away by a bullet, and which ended fatally on the fifth day from this cause. Paralysis of the lower extremities occurred on the first day; afterward, complete paralysis of the arms, etc., was superadded.² I have already presented many examples in which death resulted in the same way, that is, by paralysis of the respiratory muscles in consequence of ascending myelitis. In the following example, where the cauda equina was injured, death appears to have been caused in the same manner:—

A corporal, aged 26, was wounded by a conoidal musket-ball, July 9, 1864, in the lumbar region, and on the next day entered general hospital. Three days after that, incomplete paraplegia set in. He suffered at times from excruciating pains at the seat of the wound and in the lower extremities. Anodynes were freely given. Sphincter ani muscle paralyzed; patient delirious at times; pulse slightly accelerated. Death resulted on the 18th. *Necroscopy.*—The missile had entered at a point midway between the anterior and posterior spinous processes (upper) of the ilium, one inch below the crest, passed inward and backward, chipped the sacrum at its posterior superior angle, fractured the fourth lumbar vertebra, and lodged in the spinal canal; condition of the cauda equina and membranes not reported.³ The symptoms clearly indicate

¹ Medical and Surgical History of the War of the Rebellion, First Surgical Vol., p. 446.

² Op. cit., p. 37.

³ Med. and Surg. History of the War of the Rebellion, First Surgical Vol., p. 447.

that this also was a case of ascending myelitis. Paraplegia beginning some days after the injury was inflicted, and then gradually extending upward, with incontinence of feces and urine, delirium, and diaphragmatic breathing, are signs quite characteristic of this affection when it spreads from the lumbar, upward to the cervical region.

In respect to disordered sensations, it should be observed that the excruciating pains in the wound and lower extremities which this patient endured, arose from the spinal meningitis which attended the inflammation of the cord-substance. But patients having acute traumatic myelitis often make no complaint of pain whatever during the whole course of the disease. A case in point is related on page 371, in which the cord was severed by the missile (Fig. 870); and although the upper portion of the cord was much softened by the inflammatory process, there was no complaint of pain. Sir W. Gull's case of acute myelitis, arising from a strain of the back (related above), likewise shows that the spinal cord may be completely destroyed for a considerable distance by the inflammatory process without causing much if any pain; for, in that case, no pain whatever was complained of, excepting the pain which attended the strain itself.

Among the symptoms which are particularly bad as prognostics in cases of traumatic myelitis, we may mention gangrenous eschars over the sacrum that are rapidly enlarging, inflammations of the kidneys or bladder that are rapidly extending, ascending paraplegia—paralysis of the upper extremities appearing some days after that of the lower extremities, etc., has occurred—and diaphragmatic breathing, especially when the latter is attended by dyspnoea and bronchial râles, for then the end may be quite near.

But, although the prognosis of traumatic myelitis is generally unfavorable, we are still not entirely without hope during the first stage of the disease; for, in the case of the cavalryman, aged 35, whose death suddenly resulted from hæmoptysis the case is related on page 411, the disease was shown by the necroscopy to be undergoing resolution; and in the *foudroyant* case of traumatic spinal meningitis related on page 402, potassium iodide and ergot were administered with a notably good effect upon the inflammation (acute hyperemia) which attended the injury of the cord-substance, and preceded the inflammation of the spinal membranes.

Treatment.—Stromeyer says: "In a case where a bullet, entering laterally, bruised the third and fourth cervical vertebræ severely, and was not extracted, death resulted from the advance of inflammation of the spinal cord and brain; there was at first paralysis of the arm belonging to the injured side; it was followed by incomplete paralysis of all the limbs, ending in coma. Antiphlogistic treatment had been entirely neglected."¹ The patient afflicted with acute traumatic myelitis should always be placed on a water bed. In other respects the prophylaxis and treatment of this disease are the same as for traumatic spinal meningitis (see page 408).

For an account of the prophylaxis and treatment of sacral eschars (so-called bed-sores), and of vesical and renal inflammations which result from myelitis, the reader should consult the sections specially devoted to those topics.

In regard to the treatment of chronic myelitis with paraplegia, I will briefly mention a case which was successfully managed by Dr. C. Taylor.² The disease had lasted eleven months before the treatment was commenced. This consisted in the administration of ergot and belladonna, potassium iodide, and cod-liver oil, with alternated cold and hot flapping of the back, twice daily, and a cold douche followed by violent rubbing with mustard every morning. Complete recovery, excepting some slight want of ability to guide

¹ Op. cit., p. 38.

² British Med. Journal, May 24, 1862.

the legs, was obtained. The symptoms were very well marked; the treatment was, therefore, founded on an accurate diagnosis. It will also be remembered that belladonna (per orem) gave notable relief to vesical and urethral hyperæsthesia in one of the cases related above. In at least three instances belonging to the same category as Dr. Taylor's patient, I have seen much benefit derived from the fluid extract of ergot and potassium iodide. In one case where there probably was constitutional (tertiary) syphilis, corrosive sublimate (gr. $\frac{1}{16}$ thrice daily) did good. Concerning belladonna, Brown-Séquard justly remarks that no other medicine known has so much power to diminish the reflex faculty of the spinal cord.¹ Nux vomica and strychnia are never admissible in the treatment of this disease, because they increase the amount of blood in the cord.

SACRO-GLUTEAL ESCHARS, AND OTHER SO-CALLED BED-SORES, ARISING FROM LESIONS OF THE SPINAL CORD AND SPINAL NERVES.

These affections so often present themselves in cases of spinal injury, and usually give so much trouble to both surgeons and attendants, as well as to patients, whenever they do appear; and finally, they prove so frequently to be the proximate cause of death in fatal cases of spinal injury, that a special consideration of them is demanded in this place. There are two important varieties of these eschars or sores which are met with in cases where the spine is injured; and they differ very widely in respect to their causation, the gravity of their prognosis, and the remedial measures that are necessary. These distinct kinds or varieties of bed-sores are: (1) the *common*, or that which is often met with in cases where there is no spinal injury nor spinal disease, as well as in cases where the spinal column is injured; and (2) the *neurotrophic* or *neuropathic*, or that which arises from some morbid excitation or disease of the spinal cord or spinal nerves. The former has long been known; the latter was first described by M. Brown-Séquard.

(1) The *common* kind of bed-sore is liable to occur in all injuries or diseases which are attended with inability on the part of patients to move themselves or change their positions in bed; for instance, in certain fractures of the femur, and in certain forms of disease or injury of the hip-joint, etc., as well as in fractures and dislocations of the spinal column. In such cases the patients, unless properly cared for by others, will continue to lie in one settled or unchanged position all day, and all night, perhaps for several days and nights together. Hence, the whole weight of their hips will press with concentrated energy upon the integuments which cover the most projecting points of their pelvis. The skin and fasciæ overlying the superficial, convex, and irregular surface of the sacrum sustain the principal pressure. That compression interrupts the circulation; the blood which ought to enter the compressed tissues is prevented from doing so; the blood already there is squeezed out; the vessels are tenantless. An additional evil remains; it is almost impossible, with even the greatest care, to prevent some urine, perhaps but very little, from trickling into the bed-clothes or down the private parts. Furthermore, in spite of every attention, the fecal discharge lodges about the anus, to greater or less extent, and gets mixed with the urine. The integuments of the nates may become macerated in this stinking mixture, and then its liquid portion will act on the sodden tissues like an escharotic substance. It is, therefore, not surprising that the integuments covering the sacrum, etc., when subjected to the destructive influence of pressure too con-

¹ Op. cit., pp. 175, 176.

stant or long continued, combined with that of decomposing urine and feces, should soon become converted into an eschar, a slough, or a bed-sore. For a further account of the common variety of bed-sore—of its symptoms and treatment—the reader is referred to Prof. Moore's Article in the First Volume of this Work, pp. 800–802.

(2) The *neurotrophic* or *neuropathic* variety of bed-sore appears to have been clearly understood for the first time by M. Brown-Séquard, as already intimated, for he first demonstrated by experiments on animals the peculiar nature, as well as the causal relations and causal indications for treatment, of this important lesion. The celebrated Dr. Bright, however, had already been so much struck by its chief clinical features that he caused drawings and models in wax illustrating them to be prepared; and he, likewise, related four examples in point in his "Reports of Medical Cases."¹ But M. Brown-Séquard, after prolonged research and reflection, and after making numerous experiments on animals, to elucidate this lesion, remarked concerning it, in 1858, as follows:—

"The production of sloughs on the sacrum cannot be considered as an effect of prolonged pressure [from the decubitus] upon the parts of the skin where they appear, [inasmuch] as they sometimes are produced in a few days and even in a few hours after the fracture. They result from a *morbid excitation* of the spinal cord, and not from the *loss of action* [*paralysis*] of that nervous centre owing to its partial or complete section, as I have proved by experiments [on animals] showing that they never occur after [simple] section of the cord. The proof that pressure upon the sacrum has but a slight influence in their production, is clearly given in the case of animals on which, after fractures of the spine, I have seen sloughs occurring in parts that were not subjected to pressure. Besides, it is known that men who are confined to bed by other causes than a nervous complaint, may bear pressure upon the same part of the body for a long time without producing sloughs. Pressure upon the sacrum is, therefore, only an additional cause of sloughs. For the mode of action of the nervous system in producing alterations of nutrition,² and I will only say here that an irritation, and not a paralysis, is the cause of these morbid changes."³

Among the points established in the lecture to which he refers, are the following:—

(1) The phenomena of reflex action, that is, pains and muscular contractions in the peripheral parts, can also be produced by directly irritating either the spinal cord as a compound nervous centre (that is, a series of nervous centres arranged one above another), or the spinal nerves which issue from it.

(2) "The phenomena of this *direct* irritation have very often been mistaken for consequences of the absence of action in the nervous centres. I will merely point out here the rapid sloughs that are observed after fractures or luxations of the vertebral column, and the rapid change of the urinary secretion in similar cases."⁴

(3) "I will only add, as regards the influence of the pressure on the spinal cord producing sloughs on the nates and other morbid changes, that it is

¹ Op. cit., vol. ii. pp. 383, 423, Diseases of the Brain and Nervous System. London, 1831.

² For more details on the capital point that it is chiefly owing to a morbid action of the nervous system that alterations of nutrition take place in diseases of that system, and not, as generally supposed, to a paralysis, that is, to a cessation of the action of that system, see *Journal de Physiologie*, 1859, p. 112.

³ Brown-Séquard's Lectures on the Physiology and Pathology of the Central Nervous System, etc., pp. 248, 249.

⁴ Ibid., p. 176.

chiefly in exciting a persistent contraction of the bloodvessels in the parts where nutrition or secretion is morbidly altered, that the pressure on the cord acts. As it often happens that death, after a fracture or a luxation of the spine, is due to the slough formed on the nates, I think I must remark that a very good means of dilating the bloodvessels consists in exhausting their irritability by applications of powerful galvanic currents."¹

"To complete the demonstration of the proposition that death after fracture of the spine is usually due to the effects of the excitation of the spinal cord by pieces of broken bone [by ecchymosis from contusion of its substance, and by inflammation of its substance], and not to the results [merely] of a partial or complete section of this nervous centre, we will only say that there are many cases on record showing that a section or even a crushing of the spinal cord has not proved fatal [in man], and that in animals death is rarely caused by a partial or complete section of the cord in the dorsal region, while they die as quickly and as often as men after a fracture of the spine, if the broken pieces be not removed [and if myelitis, etc., be not prevented]."²

There is no doubt, then, that the eschars in question result not from mere division of the cord-substance, whether partial or complete, but from *morbid excitation* of that substance arising either from the irritation that is caused by the contact of foreign bodies, *e. g.*, splinters of bone and extravasations of blood, or from the inflammatory process acting upon its histological elements, when it is aroused by the injury.

This remarkable affection of the parts situated at the peripheral extremities of the spinal nerves, which results mainly from central causes, Samuel has proposed to characterize by naming it *Decubitus Acutus*, and Charcot has accepted the appellation.³ Nevertheless, this term is far from being satisfactory, *first*, because the term "decubitus" is commonly applied to the posture of the patient in bed, which has generally but a small share in the production of the disease; and, *secondly*, because in some strongly marked examples on record, the "decubitus" has had nothing whatever to do in causing the peripheral gangrene, as, for instance, in the following highly instructive case, which has already been several times referred to:—

The late Dr. D. S. Conant⁴ presented to the New York Pathological Society, together with the osteological specimen, an account of an interesting case, in which the last dorsal and the first lumbar vertebræ were fractured, and the spinal cord severed by an osseous splinter from the laminae of the first lumbar. Within six days after the casualty, an immense, gangrenous blister formed on the inner side of each thigh without any apparent cause.

A stout man, aged 55, was blown off from the rigging of a ship on which he was at work, by a high wind, on a certain Monday. He hit something in his descent and turned over, but finally struck heavily upon his shoulders. When taken up by his comrades, he was completely paralyzed in both lower extremities. Three days afterward, Dr. Conant saw him in consultation, and found that there was complete loss of sensibility and motion below a certain well-defined line extending around his body. There was also noticed a posterior angular deformity of the spine at the dorso-lumbar junction, and Dr. Conant diagnosed fracture with crushing of the body of the twelfth dorsal vertebra, and with fragments of bone impinging upon the spinal cord. The patient went on very well until the Saturday following the injury, his mind remaining perfectly clear. On Sunday morning his physician noticed a large blister on the inner side of each thigh, and extending nearly the whole length thereof, unconnected with any previous local irritation. At four o'clock he had a chill, his mind till then having remained clear. But soon after he became delirious, and quietly died

¹ Ibid.

² Ibid., p. 250.

³ Lectures on the Diseases of the Nervous System, translated by Dr. G. Sigerson, p. 57. Philadelphia, 1879.

⁴ American Medical Times, June 1, 1861, pp. 359, 360.

without any convulsions at seven o'clock the same evening, six days and some hours after the accident, apparently in consequence of septicæmia.

Autopsy.—There was a considerable quantity of extravasated blood on each side of the spinal column, in the vicinity of the last rib. The body of the last dorsal vertebra was found crushed, and a little piece of bone from the laminae of the first lumbar vertebra had cut the spinal cord entirely off. The blisters on the inner sides of the thighs were found to be the results of mortification. The internal organs were all healthy. No statement is reported as to the presence of a sacro-gluteal eschar, but without doubt there was a large one formed by Saturday, when it was noted that the patient was not doing so well. It is mentioned that there was but little disturbance of the pulse, notwithstanding that mortification was occurring in the lower extremities. The textural condition of the spinal cord, aside from its complete division by a fracture-splinter, is not described. The gangrenous inflammation of the thighs was thought to be due to "injury of the sympathetic ganglia situated at the angles of the last two ribs." But, inasmuch as in other cases belonging to the same category, similar eschars have appeared when vaso-motor paralysis has been completely wanting, it is only fair to infer that in this case the gangrenous lesions of the thighs arose from morbid excitation of the spinal cord, which is merely another name for traumatic myelitis, at least in this particular instance.

Again, in the following example of *chronic myelitis* arising from concussion of the spinal cord, at the lower part thereof, where the resultant paraplegia was very far short of being complete, an ulcer or slough of large size presented itself in the integuments over the sacrum, although there had been no absolute confinement to bed at any time:—

Professor Wm. A. Hammond¹ relates the case of an originally healthy married woman, aged 22, admitted into the Baltimore Infirmary, on March 14, with chronic myelitis, the result of an injury. She was a sober, intelligent young woman, by occupation a weaver, four years married, and the mother of a child then three years old. She had always been healthy until her present illness, excepting that in girlhood she had been affected to some extent with rheumatism and occasional epistaxis.

Eleven months before admission, whilst in a somnambulistic state, she fell from a second-story window, and struck the hand-rail of a porch in her descent, injuring her back about the junction of the lumbar vertebrae with the sacrum. The immediate consequences were pain in that region, soreness across the abdomen, and the passage of bloody urine. For seven months catheterization was necessary, after which time the bladder in a measure recovered its contractility, but soon lost it again, the sphincter also becoming paralyzed. Severe cough likewise ensued; and the catamenia, heretofore quite regular, entirely ceased. There was slight paralysis of the lower extremities from the time of the accident, which gradually increased until considerable difficulty was experienced in walking, or even in standing. There was also deficient sensibility in both lower extremities, and likewise over the sacral region. Soon after the accident, the sphincter lost its power. From the first, she experienced more or less numbness and spasm in her lower extremities. She had been treated by cupping the lumbar and sacral regions, and by strychnia.

At the time of admission, there was complete paralysis of the sphincters of the bladder and rectum. Her urine was constantly flowing from her, and the moment her feces entered the rectum it was evacuated. Upon introducing a finger into the bowel, it was found to be entirely relaxed; and, in fact, three or four fingers could be inserted with ease. Her lower extremities were partially paralyzed. Although she could still walk, she did so with difficulty. Frequent cramps and almost constant formication were present, and there were occasional startings of the limbs without her being aware of them. There was a good deal of pain in the sacral region; and, as is usual in such cases, a large ulcer existed in the same locality.

On applying the æsthesiometer to the anterior surface of her legs and thighs, to those parts which are supplied by branches of the lumbar plexus of nerves, there was no diminution of sensibility found. She appreciated the two points when separated only

¹ American Medical Times, June 15, 1861, pp. 379-381.

to the extent of half an inch. But, on applying the instrument to the posterior surface of her legs and thighs, to the parts which are supplied by the sacral plexus, she was conscious of but one impression. Even when the points were separated to the extent of five inches, but one impression was perceived; and, over the gluteal and sacral regions, she could not feel them at all. It was therefore evident that the disease affected the portion of the spinal cord from which the sacral plexus arose—namely, the lower portion. In addition, it was found that the sphincters of the bladder and rectum, which likewise derive their nerve-filaments from the same plexus, had lost their contractile power. There was a sense of constriction also present, and the urine was strongly alkaline.

The *diagnosis* of chronic myelitis was founded on the fact that for a long time the patient had experienced constant pain at the point where the healthy and diseased portions of the cord united; that there was a sense of constriction also present there; that there was a feeling of numbness almost constantly present in the paralyzed portions of her body; and, frequently, other morbid sensations, such as coldness, burning, formication, etc.; that there were oftentimes reflex-motor spasms in the lower extremities; that there was well-marked anæsthesia in the portions of cutaneous surface supplied by nerves issuing from the diseased part of the spinal cord; that the sphincters of the anus and bladder were paralyzed; that the normal movements of the lower extremities were considerably impaired; that there was a large slough over the sacrum; and that the urine was strongly alkaline.

The *treatment* consisted in administering ergot in moderate doses by the mouth, and belladonna by the skin, by applying thereto a large plaster made of that remedy; fresh air, moderate exercise, and a good, nutritious diet were also enjoined. The sacral slough was treated by the method recommended by M. Brown-Séquard (which will presently be described), and by applying galvanism.

May 16. The patient has recovered full control over the bladder, the rectum, and the extremities; her ability to walk is also very much improved. The slough over the sacrum has been entirely cured. The pain has almost entirely departed from the cord, and she is no longer troubled with cramps or numbness in the lower extremities. This highly beneficial plan of treatment is to be continued until the cure is complete.

The history of this exceedingly instructive case I have presented as briefly as seemed consistent with elucidating in a satisfactory manner the symptoms, the diagnosis, and the therapeutics of this sometimes obscure and often very troublesome disorder of the spinal cord; and by so doing I have really saved the use of many words and even paragraphs in the way of abstract description, which ultimately would have been required.

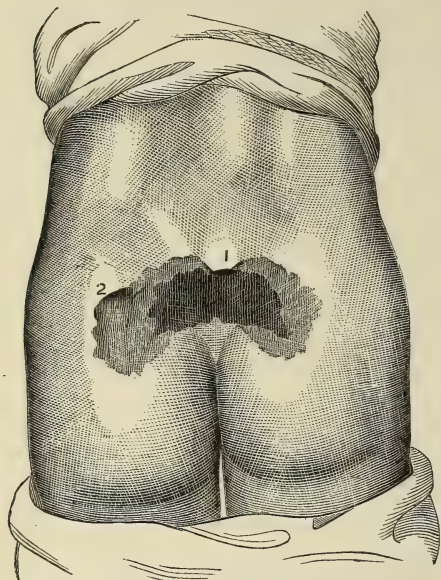
Thus I have presented two important examples in which the patient's "decubitus" had no part whatever in the production of the eschars in question, and in the latter of them the eschar was not even "acute." It is, therefore, quite evident that the term "decubitus acutus" is not at all appropriate for such instances, as well as not particularly appropriate for any instance of the lesion under consideration; and with a view to indicate at the first glance the nervous origin of these sloughs, I have ventured to call them *neuropathic eschars*, that is, eschars which arise mainly in consequence of morbid excitation or disease of the spinal cord itself, or of the spinal nerves that supply the parts on which the eschars are formed.

Symptoms of Neuropathic Eschars.—The first sign of this disorder is an erythematous patch on which vesiculæ and bullæ are rapidly developed; mortification of this patch of the skin and subjacent tissues very often ensues.

When this disorder appears in consequence of a lesion of the spinal cord, it usually presents itself in the sacral region. Here it is bisected vertically by the median line; and it extends itself symmetrically, on either side, into the adjacent integuments. (Fig. 882.) But it may likewise appear on almost any part of the trunk or the members that may be subjected, by posture, to a somewhat continuous pressure. In certain cases, a very slight and a very short pressure suffices to determine its appearance. Finally, there are some

cases, the number of which is probably not very great, wherein it seems to be produced without the intervention even of the least degree of pressure, or of any other cause of a similar kind. I

Fig. 882.



Showing a sacro-gluteal eschar of neuropathic origin, which was formed in a case of myelitis involving the dorsal portion of the spinal cord: 1. The mortified part 2. The erythematous zone. (Charcot.)

gory.

This disorder is quite distinct from the various cutaneous eruptions which are seen not unfrequently in the sacral region of patients condemned by different affections to long maintain a recumbent posture in bed. These eruptions, which sometimes are erythematous and lichenoid, sometimes pustular and ulcerous, sometimes papular, and having a deceptive resemblance to syphilitic sores (*plaques muqueuses*), are generally caused by repeated and prolonged contact with irritating substances, such as decomposing urine and fecal matter. They, as well as the neuropathic erythema and blebs, may become the starting points of genuine eschars, as already stated above. But the neuropathic eschar is often distinguishable, clinically, from that of the former, by certain important characteristics, namely: (1)

By appearing shortly after the primary disorder of the nerve-tissue, or by following upon a sudden exacerbation of that disorder; and (2) By exhibiting a very rapid evolution. (Charcot.)

Some days, or, it may be, only some hours, after the causative affection of the spinal cord has manifested itself in such cases, there appear on certain portions of the skin, already mentioned, one or several erythematous patches, variable in extent and irregular in shape. The skin here has a rosy hue; sometimes, however, it is dark-red, and even violet, but still the color disappears momentarily on making pressure with a finger. M. Charcot has ascertained that in such cases the derma is, anatomically, infiltrated with leucocytes, as happens in erysipelas.¹ Occasionally, but, for the most part, in examples of myelitis, there appears besides an apparently phlegmonous tumefaction, involving the derma and subjacent tissues, which may be attended by acute pain, if the affected part have not been previously stricken with anæsthesia.

In a day or two, but sometimes sooner, vesicles or bullæ make their appearance about the middle of the erythematous patch; they contain a liquid substance or serosity, which is sometimes colorless and perfectly transparent, and sometimes more or less opaque, reddish, or of a brownish hue.

If the causative affections of the spinal cord or spinal nerves now abate, the vesicles and blebs soon wither, dry up, and disappear. Sometimes, however, the blistered epidermis becomes torn, drops off in pieces, and lays bare a bright-red surface strewn with violet points or patches, corresponding with a sanguinolent infiltration of the cutis vera. In such cases, the subcutaneous connective tissue, and sometimes even the subjacent muscles, are likewise invaded by the sanguinolent infiltration. This fact M. Charcot has repeatedly verified by post-mortem examination.²

¹ Op. cit., p. 58, foot-note.

² Ibid., p. 58.

These violet-colored points or patches of sanguinolent infiltration rapidly widen, and soon their edges run together or coalesce. Thus, in a short time, there supervenes in the affected part a mortification of the cutis vera, which is at first superficial, but soon becomes profound, and may involve not only the subcutaneous connective tissue, but likewise the subjacent muscles, and even the subjacent bones. Thus the eschar is constituted in the neuropathic cases under consideration. If there be some chance for a favorable issue still remaining, the work of reaction against, and elimination of, the mortified tissues at once begins; and, should the prospect become more favorable, a period of reparation will follow, which, however, is liable to exhibit many fluctuations in its course.

It should have been stated that in cases of typhus and typhoid fever, a cutaneous affection of the sacro-gluteal region, etc., not unfrequently occurs, which bears a strong resemblance to the neuropathic bed-sore now under consideration, and which, perhaps, arises in part from analogous conditions. This cutaneous affection of the buttocks, in typhus and typhoid fevers, has been minutely described by Piorry, in France, and by Pfeüfer, in Germany.

In the production of neuropathic bed-sores, the patient's posture in bed often plays an important part. For instance, it is not unusual in cases where the patient is so placed as to repose on his side, during part of the day, to find, in addition to the sacral eschar, large necrotic ulcerations occurring over the great trochanters. It is also quite common to see in cases of spinal injury attended with paralysis, that the different parts of the paralyzed limbs which are exposed to only slight and brief pressure, such as the ankles, heels, and inner surfaces of the knees, present lesions characteristic of neuropathic bed-sores. On page 269 (*supra*), I have presented, with a wood-cut (Fig. 852), an abstract of the case of a soldier whose spinal cord was severed by a knife opposite the fifth cervical vertebra; neuropathic sphacelus soon followed, attacking all the projecting points on the lower part of his body, and proceeding rapidly until it almost bared the sacrum. In some rare instances, I have also seen neuropathic eschars present themselves over the scapulæ and over the olecranon process.

Clinical Relations.—In the foregoing pages I have mentioned or referred to a great many cases in which neuropathic eschars appeared in connection with fractures or dislocations of the vertebræ, and consequent injury of the spinal cord. In regard to the time when the symptoms of neuropathic eschars are most likely to present themselves in cases where the spinal column is injured, Dr. E. Gurlt, whose opinion on this subject is based on the study of a very large number of cases, holds that the first symptoms of this affection usually appear from the fourth to the fifth day after the accident. But the initial erythema and bullæ may appear very much earlier than that; for, on page 315 (*supra*), I have presented, with a wood-cut (Fig. 859) illustrating the vertebral lesion, the case of a soldier who dislocated the fourth cervical vertebra with much displacement and much damage to the spinal cord, in a vain attempt to turn a somersault, and who survived the accident only forty-four hours; nevertheless, it was found at the autopsy that "ulceration over the sacrum had already commenced;" that is, a well-marked bed-sore was already formed. In this case, then, the initial erythema and vesicles or blebs must have presented themselves within a few hours after the accident.

The initial symptoms of a neuropathic eschar on the breech appeared in less than thirty-six hours after the injury, in a case under the late Dr. James R. Wood's care, at Bellevue Hospital:—

The patient was a stableman, aged 30, who fractured the seventh cervical vertebra by falling down stairs, at 7 P. M., on June 13. He was insensible for the moment.

On the 14th, at 6 P. M., he was admitted to the hospital, with complete motor and sensory paralysis of the entire body, below the third rib in front and the fourth rib behind. The decubitus was dorsal, with head and neck thrust forward. The respiration was purely abdominal (diaphragmatic). The penis was strongly erected. Neither urine nor feces had been passed since the accident.

On the 15th, A. M., a red spot, nearly two hands' size, was observed upon the left nates, and vesication in the fissure near the extremity of the coccyx. In the evening, marked increase of temperature all over the surface of the body was found, and a purplish spot, the commencement of a slough, low down in the cleft of the nates.

On the 16th, A. M. A purple spot commencing over the third or fourth lumbar vertebra; some hæmaturia; and considerable tympanites. 7½ P. M. Great dyspnoea; bronchial tubes and trachea filled with secretion.

On the 17th. The incipient bed-sores no further developed; patient delirious at times through the day. 7 P. M. Entire anæsthesia and paralysis of both arms—they were not paralyzed early in the afternoon; great tympanites; urine high-colored; priapism always induced by passing the catheter; was conscious and sane. 9 P. M. Comatose and insensible; eyes suffused; convulsive movement of lower jaw; body still hot; pulse full and strong. 11¾ P. M. Died quietly, comatose, and without general convulsions, four days plus four and three-fourth hours after the accident. *Autopsy.*—Body of seventh cervical vertebra fractured transversely and completely; ligamenta subflava completely disrupted; the vertebra dislocated; spinal cord not lacerated; brain moderately congested. Pathological condition of the cord not described.¹ The ascending and deepening character of the paralysis, however, denotes, under the circumstances, that there was ascending myelitis.

In a case related on page 390 (*supra*) the initial symptoms of neuropathic sphacelus simultaneously occurred at several different points in the lower extremities, in less than twenty-four hours after the spinal lesion:—

The patient was a derrick-man, aged 41, admitted to Bellevue Hospital, in Dr. Stephen Smith's service, two hours after he had sustained a fracture of the tenth dorsal vertebra, with complete paraplegia, in consequence of being thrown from a cart and striking his back upon the stony street. Next morning it was observed that sloughs had commenced to form upon the heel and upon the ball of the great toe of his left foot, and over the external malleolus of his right ankle, without any apparent cause; several hours afterwards, death ensued in consequence of compression of the spinal cord by extravasated blood.

In a case recorded by Dr. L. Buchner, of Darmstadt, in which a man, aged 46, had sustained complete diastasis of the sixth and seventh cervical vertebræ by falling from a height, and in which death supervened sixty hours after the accident, a well-marked bed-sore of spinal origin was already visible. (Gurlt.)

It has been claimed by many that *anæsthesia* is an essential factor in the causation of bed-sores having a spinal origin. This view, however, is negatived by the case of a young woman, aged 22, related by Professor Hammond, which I have presented on page 420; for, in that case, a large sacral eschar appeared, although the patient had never been confined wholly to bed, and had never been entirely unable to walk; and, therefore, of course, had never had complete paraplegia, nor anything like profound anæsthesia.

This view is also negatived by an example of vertebral fracture reported by Jeffreys:—²

The patient was a man, who was injured by a fall of twenty-five feet from a ladder. There was much shock, with a cold skin, and a barely perceptible pulse. All the parts below the fracture were deprived of sensibility and voluntary motion. Next day there was persistent priapism; "then supervened phlyctenæ in the region of the sacrum;" and, on the same day, "the patient recovered his sensibility." Death, however,

¹ New York Journal of Medicine, January, 1859, pp. 85-87.

² London Medical Journal, July, 1826.

ensued; and, on post-mortem examination, it was found that the bodies of the seventh and eighth dorsal vertebræ were broken into several pieces, which were much displaced.

In a case where neuropathic eschars appear, priapism, strong alkalinity of the urine, hæmaturia, inflammation of the urinary bladder or kidneys, hyperæsthesia, vaso-motor exaltations or depressions of the body-heat, clonic convulsions of the paralyzed members, tonic (that is, tetanoid) spasms occurring in paroxysms, in brief, all those symptoms which usually reveal an excited state of the spinal cord and spinal membranes, often precede, accompany, or closely follow the formation of these eschars.

When the injuries (traumatisms) or the secondary lesions which excite the spinal cord in cases where neuropathic eschars ensue, affect the cord symmetrically, the eschars themselves, as a rule, are symmetrically developed, as shown by Fig. 882; as also happened in Dr. Conant's case, where a large gangrenous eschar, of an equal size, presented itself on the inner side of each thigh; and as in Dr. Stephen Smith's case, referred to above, where sloughs of similar size and appearance simultaneously formed on each foot and ankle, in consequence of spinal injury. But, when the traumatism affects one side only of the spinal cord, then the neuropathic eschars which arise therefrom are not symmetrically developed; they are found only on the side of the body opposite the side of the cord which is injured or diseased. For example, in the case of a man admitted into Professor Nélaton's ward at the St. Louis Hospital, for a sword-wound of the back dividing the left half of the spinal cord (I have already presented a pretty full account of this case on page 394), "a slough formed on the right side of the sacrum, although the patient had not felt anything there." The man, however, recovered. The same peculiarity has been observed in several analogous cases; and, according to M. Brown-Séquard's experiments, it is a constant fact in the case of animals.

The information derived from M. Brown-Séquard's experiments in this regard, is capable of giving so much practical aid or useful help to surgeons in diagnosing spinal lesions and spinal disorders, that I will briefly refer to them in this place. We learn first from these experiments, that after wounds dividing one lateral half of the spinal cord, there supervenes in animals motor paralysis of the lower extremity on the same side as the lesion of the cord. This limb also presents exaltation of tactile sensibility (hyperæsthesia) in a more or less marked degree, and it likewise exhibits a notable elevation of temperature correlated with vaso-motor paralysis. But the opposite limb, on the contrary, retains the normal temperature and the normal power of motion, whilst its tactile sensibility is much lessened, or may even be extinct; that is, it exhibits anæsthesia and sensory paralysis. All these phenomena or symptoms are exactly reproduced in man under analogous circumstances. In his case, as in that of animals, we may also find various trophic derangements rapidly supervening in the peripheral parts of the body, which manifestly arise from the spinal lesion. Among the consequences of these trophic derangements I have already mentioned *bed-sores*, occurring not on the injured side, where the voluntary motor and vaso-motor paralysis is to be found, together with exaltation of temperature and hyperæsthesia, but on the opposite side of the body, particularly on the opposite side of the sacral region, that is, on the side where the motor functions, both voluntary and vasal, are unimpaired, and where there exists only a deadening of the sensibility, or anæsthesia. This circumstance clearly shows that neuropathic bed-sores do not arise from vaso-motor paralysis, as some persons have vainly imagined.

In man, other nutritive lesions of a similar character have been observed.

I shall here take space to mention only two of them, namely: (1) Rapid diminution of the faradic contractility of the muscles, soon followed by an equally rapid atrophy of the muscles themselves, or *acute muscular atrophy*; and (2) A peculiar form of joint-disease inflammatory in character, or *spinal arthropathy*. It is, however, a remarkable fact, that while the spinal or neuropathic eschar, in cases where the cord is partly divided, appears on the side of the sacrum opposite the spinal injury, the arthropathy and the muscular atrophy are to be found in the limb belonging to the same side as the spinal injury. For example, in the case of a man who was admitted into Professor Nélaton's ward with a sword-wound dividing the left half of the spinal cord (already twice mentioned), the symptoms showed rapid improvement up to the twelfth day after the casualty; on that day it was remarked that, without apparent cause, the *left* leg, still more sensitive than normal, had increased in volume, and that a quantity of fluid had accumulated in the left knee-joint sufficient to float the patella half an inch above the condyles. Two or three days subsequently, an eschar was observed occupying the *right* lateral part of the sacrum and the right gluteal region.¹

Another very instructive example, which occurred in one of Dr. Cusco's patients, is related by M. Charcot, and I will present a brief abstract of it:—

A man, aged 40, was stabbed with a poniard, in the night of February 15–16, 1871, at the third dorsal vertebra, and on the left side thereof. The weapon penetrated downward and toward the right, and divided the *left* half of the spinal cord. The left leg was immediately stricken with motor paralysis, while the right was not. He was at once brought to hospital. In the morning the following note was made: *Left* lower extremity, complete motor paralysis; limb perfectly flaccid; no trace of contraction, nor of rigidity; no spasmodic movements, nor subultus. But its sensibility is greatly exaggerated; the least touch of the skin, especially near the foot, causes pain; pressure has the same effect; a slight pinch or a tickle is followed by very painful sensations; the application of a cold body produces painful sensations which the patient compares to prickings. *Right* lower extremity, the voluntary motions are all perfectly normal, but the sensibility is almost completely destroyed; complete analgesia; sensitiveness to touch almost null; the contact of a cold body causes an obscure, dull, prickling sensation. The insensibility is not restricted to the lower limb; it ascends to a level with the right nipple. The urine and feces passed involuntarily.

On the 24th, it was noted that the left (motor-paralyzed) limb was warmer than the right; and that the patient complained of feeling constricted or compressed at the base of the thorax.

On March 5th (seventeenth day), the patient complained of troubled sight: left pupil contracted more than right pupil; the vessels of left eye more numerous and voluminous than those of right eye. The evacuations, for the last two days, had again been voluntary. The state of the lower extremities remained unchanged.

On the 13th (twenty-fifth day), the *right* buttock, since the day before, had been the seat of livid redness, and the epidermis had already fallen off from a part of the erythematous patch.

On the 14th, the integuments on the *right* buttock, near the sacrum, were denuded to the extent of a crown-piece, and ecchymosed—that is, there was a *spinal bed-sore*. The *left* knee-joint was red and swollen, and likewise the seat of spontaneous pains, which were increased by moving the joint—that is, there was *spinal arthropathy*.

On the 24th, an ulceration had occurred on the *right* buttock, on a level with the ecchymosed patch, which now was covered with granulations. The *left* knee was almost free from redness and swelling, as well as from pain.²

The following very instructive example of *acute muscular atrophy*, taken from Dr. W. Müller, is likewise presented by M. Charcot:—³

¹ Brown-Séquard, *Journal de la Physiologie*, t. iii. p. 130.

² *Op. cit.*, p. 70.

³ *Ibid.*, pp. 70, 71.

The patient was a woman, aged 21, who was stabbed with a knife in the back, at the fourth dorsal vertebra; the weapon, as the autopsy afterwards demonstrated, divided the *left* lateral half of the spinal cord, two millimetres above the third pair of dorsal nerves. On the first day, complete paralysis of motion and hyperæsthesia were observed in the *left* lower extremity; the opposite limb was anæsthetic, but not paralyzed. On the second day it was found that the muscles of the paralyzed member, and of the lower part of the abdomen, gave no reaction under faradic stimulation, whilst, in the corresponding parts of the opposite side, the electrical contractility continued normal. On the eleventh day, a neuropathic or spinal eschar was formed, which occupied the right sacro-gluteal region, and extended to the right gluteal eminence. It was also remarked, on this day, that the paralyzed limb had notably wasted away, and measured about two inches less in circumference than the anæsthetic member. On the thirteenth day, death occurred. At the *autopsy*, the borders of the spinal wound appeared tumefied, and of a reddish-brown color; a thin purulent layer covered it. Below the wound, the left lateral column presented the anatomical characteristics of descending myelitis, throughout its whole length.

Thus, we find that when the neuropathic or spinal bed-sore appears on but one side of the sacrum, or on one buttock only, in consequence of injury or division of the lateral column belonging to the opposite side of the spinal cord, the eschar is liable to be accompanied by a peculiar joint-disease of spinal origin, or by an acute muscular atrophy, also of spinal origin, which affections, however, both occur on the side opposite the neuropathic eschar—that is, in the lower extremity belonging to the same side as the spinal lesion. These clinical facts, and the intimate clinical connection which exists among these disorders when they are developed under the circumstances just mentioned, should be known to all surgeons.¹

Continuing our inquiry into the clinical relations of neurotrophic or neuropathic eschars, we shall next find that they may arise from those forms of traumatic myelitis which are not attended by wounds of the spinal cord, nor by fractures, nor by dislocations of the spinal column. We shall likewise find that they may arise from this cause quite as rapidly as they would if the spinal column were also fractured. A case reported by Sir W. Gull, which I have already presented on page 414 (*supra*), clinically illustrates in a useful manner this mode of causation:—

The patient was a laborer, aged 25, who felt a sudden pain in his back, after lifting a heavy weight. On the morning of the second day afterward, his lower extremities were completely paralyzed. Two days later he entered hospital. A bed-sore had already begun to form near the sacrum, and ammoniacal urine dribbled from the bladder." Death occurred forty-one days after the strain. *Autopsy*.—A large bed-sore had bared the sacrum in its whole length. The bones and ligaments of the spine exhibited no trace of injury. The spinal cord was disorganized by myelitis opposite the fifth and sixth dorsal vertebræ.

In this example of acute myelitis resulting from a strain of the back, the bed-sore began to appear within four days after the injury, and two days after the symptoms of myelitis had declared themselves. I have also presented on page 420, as will be remembered, the case of a woman, aged 22, reported by Professor Hammond, in which myelitis arising from concussion of the spinal cord, the result of a fall, was attended with the formation of a large sacral eschar.

¹ There are, however, unilateral bed-sores also of cerebral origin—that is, bed-sores which arise from diseases of the brain, such as cerebral hemorrhage, cerebral embolism, cerebral softening, etc.—which appear on one cheek only of the nates, but they do not come within the scope of this article. I will merely remark here: (1) that the acute bed-sore which arises from cerebral diseases does not essentially differ from that which arises from spinal lesions (Charcot); (2) that the cerebral bed-sore can usually be distinguished with ease from that which is of spinal origin; and (3) that a full account of the genesis of cerebral bed-sores, illustrated with a wood-cut, is to be found in Charcot's Lectures on the Diseases of the Nervous System, p. 63.

But *spontaneous* acute myelitis, as well as *traumatic* acute myelitis, very often determines the precocious formation of sacral eschars, especially when it sets in suddenly and its evolution is rapid. Many instances belonging to this category have been placed on record by Gull, Duckworth, Joffroy, Engelken, Voisin, and Cornil, as well as by other observers.

We may also see a sacral eschar rapidly form in cases of spinal disease where the evolution is slow, should a new irritation of an active character suddenly intervene, or should an acute inflammatory process be suddenly superadded to the preëxisting lesion. Not only the exacerbations of partial sclerotic myelitis, but also the sudden invasion of the rachidian cavity by purulent matter emanating from an abscess, in the case of patients suffering from vertebral disease, may cause the rapid formation of sacral eschars. Should a tumor occupying the central part of the cord provoke the development of acute myelitis by its presence, the same result will follow. Several examples of this kind are on record. (Charcot.)

Neuropathic sphacelus of the integuments on the sacrum and nates may be caused by *traumatism of the cauda equina*, as well as by morbid excitation of the spinal cord itself. This important fact is proved by a case reported by M. Couyba,¹ and mentioned by M. Charcot:—²

A young soldier received a shot-wound at the outpost of Clamart. The missile entered his left side near the anterior extremity of the tenth rib, and emerged on the right side of the spinal column, about three inches from the spinous process, and on a level with the second lumbar vertebra. Paresis, with acute hyperæsthesia, of the lower extremities ensued. On the fifth day after the casualty, a bulla appeared on the right gluteal eminence, and quickly gave place to an eschar, which progressively extended so as at last to wholly cover the sacro-gluteal region. On the nineteenth day, death resulted.

Autopsy.—A layer of purulent matter covered the spinal cord, both anteriorly and posteriorly, from the cauda equina up to the cervical region. The cord itself, when examined, first in the fresh state, next in numerous hardened sections, did not exhibit any alterations. But a certain number of nerve-tubes in the nervous cords which form the cauda equina, presented the anatomical characteristics of fatty granular degeneration. Thus, the demonstration that a morbid excitation of the cauda equina had existed during life, was made complete. Additional examples of the same sort might be cited.

Finally, the morbid excitation of any peripheral nerve may be attended with the rapid formation of eschars in the integument belonging to its area.

For example, M. Charcot³ relates the case of a woman at La Salpêtrière, who had an enormous fibroid tumor on the left side, which compressed, in the pelvis, the roots of the crural and ischiatic nerves of the same side. There had resulted a parietic state of the corresponding member, accompanied by acute pains running along the track of the principal nerve-trunks. One morning, shortly after the appearance of the first symptoms of compression, it was remarked that an eschar had rapidly formed on the left of and near to the sacral region. Likewise, on the left knee's inner surface some pemphigoid bullæ were found, in a spot which had been pressed upon by the right knee for a considerable time during the night, in consequence of the patient's attitude while asleep; these pemphigoid bullæ were filled with a brownish liquid, and soon gave place to an eschar. Nothing of the kind was developed on the right knee.

The fact that eschars of the integument may quickly form in consequence of morbid excitation of the spinal nerves which supply the peripheral areas where the eschars themselves appear, as occurred in the case just related, affords another good reason why the terminology of such eschars should be

¹ Thèse de Paris, 1871, p. 53, Obs. xiii.

² Op. cit., p. 75.

³ Ibid.

characterized by a name which distinctly recognizes their neurotrophic or neuropathic origin.

Course and Consequences of Neuropathic Sphacelus or Eschars.—Should the disease spontaneously abate, or should the treatment prove successful, it may happen: (1) that the initial vesicles or blebs will wither, dry up, and leave a healthy surface; or (2) that the erosions, being superficial, will take on healthy action, granulate, and cicatrize; or (3) that the slough, although extending deeply, will become surrounded by a line of inflammatory demarcation separating the dead from the living tissues; that purulent matter will form throughout this line of demarcation, whereby the slough will become detached from the living tissues, so that it can be readily taken away by the surgeon; that the cavity thus formed will fill up by the granulating process; and, finally, that the space occupied by the slough, whether large or small, will become covered with new integument in the form of a cicatrix.

But not always, nor even in a majority of instances, is this fortunate issue obtained in cases of neuropathic sphacelus. On the contrary, this disorder often proves fatal, and that, too, in certain determinate ways, which I will now proceed to point out:—

(1) Occasionally, this disorder directly destroys life by causing *acute septicæmia*. That is, it sometimes happens in cases of neuropathic sphacelus that the eschars are very large, and at the same time do not become environed by any lines of inflammatory demarcation which plug with coagula the veins passing from the dead into the living tissues; wherefore these vessels remain open, and directly convey the decomposing blood, and putrid juices and putrid gases from the dead parts, into the general current of the circulation. Thus, septic poisoning of the blood, or septicæmia in its most acute form, sometimes occurs in cases of neuropathic sphacelus, and quickly destroys life. Without doubt this happened in the case reported by Dr. Conant, and already presented on p. 419, where a man had sustained vertebral fracture at the dorso-lumbar junction by being blown off from the rigging of a vessel while at work; for, on the morning of the following Sunday, a large blister of mortification was noticed on the inner side of each thigh, which extended nearly the whole length thereof; at 4 P. M. he had a violent chill, and became delirious; he sank rapidly, and died quietly at 7 o'clock on the same evening; and the *autopsy* revealed no cause for his sudden death, excepting the neuropathic gangrene and the consequent septicæmia.

A case of simple fracture of the first lumbar vertebra, with a wood-cut to illustrate it (Fig. 862), was presented on page 351, in which it is not improbable that *septicæmia* arising from a neuropathic eschar was likewise the immediate cause of death; for “the parts in the region of the sacrum were gangrenous,” and smelled so badly that it was necessary to apply strong disinfectants (chlorides), in order to suppress the stench.

(2) Neuropathic bed-sores not unfrequently destroy life by inducing *purulent infection*, or *pyæmia*, attended with the production of metastatic abscesses in the viscera. I have already mentioned a considerable number of cases in which this accident occurred, and here is another example:—

J. H. Gray¹ relates the case of a boy, aged 13, who fell thirty-five or forty feet, striking his back, and was stunned. Projection of the sixth or seventh dorsal vertebra was noted; also delirium; paralysis; priapism; incontinence of urine and feces; abnormal heat; excoriation; on ninth day cystitis; bed-sores. He did well for three weeks, but then rigors occurred, and were followed by death twenty-eight days after the accident. *Necroscopy* revealed fracture and displacement forward of the sixth dorsal

¹ London Hospital Reports, vol. i.

vertebra; cord crushed, but not compressed; metastatic deposits (abscesses) in several viscera. (Ashhurst.)

M. Charcot thinks that this sequel of spinal bed-sores is seldom met with. But experience, especially that gathered in old or perhaps infected hospitals, proves the contrary.

(3) Sphacelus of neuropathic origin not unfrequently proves fatal in consequence of the formation of *gangrenous emboli*, or the occurrence of *gangrenous embolism*. "In this variety," says M. Charcot, "thrombi impregnated with gangrenous ichor are transported to a distance, and give rise to gangrenous metastases, which are principally observed in the lungs. This is a point upon which Dr. Ball and myself have insisted in a work published in 1857.¹ But long before us, and even long before the theory of embolism had been Germanized, M. Foville² had expressed his opinion that a considerable number of cases of pulmonary gangrene, observed in the insane, and in different diseases of the nervous centres, are caused by 'the transport into the lungs of a part of the fluid which bathes the eschars of the breech.'"³ I give the preceding quotations from MM. Foville and Charcot, in order to show not only that gangrenous eschars of the sacrum may cause pulmonary gangrene through the agency of pulmonary embolism and pulmonary infarction, but also that French observers have had some share of importance in developing the theory of embolism itself.

(4) Neuropathic eschars prove fatal most frequently of all, perhaps, in consequence of *exhaustion*—that is, the sufferers die worn out by the discharge and irritation, combined with a certain degree of septicæmia which is almost always present in such cases. The process of mortification tends gradually to invade the deeper tissues, as well as to spread more widely on the surface. In this way, the trochanteric synovial bursæ may be laid open, the trochanter itself denuded of periosteum, the gluteal muscles, the nerve-trunks, and the bloodvessels of a certain calibre laid bare. But I can best describe the phenomena of sacral eschars ending in death from exhaustion, by briefly relating an example:—

A female domestic, aged 30, moderately temperate, and of good constitution, was admitted into Bellevue Hospital, on the afternoon of August 30, on account of fracture and luxation of the first lumbar vertebra, with the following history. About 9 or 10 o'clock on the previous evening, while in a somnambulistic state, she walked out of a third-floor window, and, falling two floors, struck upon the slated roof of a shed. She was not rendered insensible, even for a moment, but could give no account of the direction in which the blow was received, excepting that she struck upon her left side. No paralysis nor anæsthesia followed the accident, and no pain except upon motion. The left leg, however, had felt "numb" ever since. No urine nor feces had been passed since the accident.

Upon examination, slight deformity, a slight displacement of a vertebra backward, was detected at the position of the last dorsal or first lumbar vertebra, and very slight tenderness a trifle lower down; but no redness nor ecchymosis, nor any other external mark of injury. The respiration was natural in character and frequency; the pulse rather frequent, but of moderate strength.

The urine was withdrawn by catheter for a few days, and after that was passed involuntarily until death. The bowels acted regularly. In the course of eight or ten days after admission, the vertebral prominence increased so much as to make easy a diagnosis of luxation backward of the first lumbar vertebra. No motor paralysis nor anæsthesia of the limbs or body appeared in the case. The very intense pain occurring upon the slightest attempt at motion, which originally characterized her condition, gradually diminished, and at length in considerable measure disappeared.

¹ De la coïncidence des gangrènes viscérales et des affections gangréneuses extérieures. L'Union Médicale, 26 et 28 Janvier, 1860.

² Dictionnaire de Méd. et de Chirurg. Prat., t. i. p. 556.

³ Charcot, op. cit., p. 60.

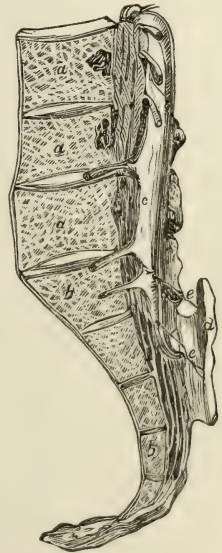
A bed-sore early formed over the sacrum, and slowly proceeded inward or deepened until exposure of the bone was effected. Subsequently, diarrhœa supervened. She sank from exhaustion; and, on October 6, she died, thirty-eight days after the accident.

Autopsy.—Crushing of the body of the first lumbar vertebra, with displacement of the entire vertebra backward, was revealed. Firm union in the fractured vertebra had taken place.¹

It is worthy of particular mention that a sacral eschar attacked this woman although she had no sensory nor motor paralysis whatever, that the eschar soon followed the accident, that it steadily deepened until it laid bare the sacrum, and that it caused death by producing exhaustion. The sacrum itself was probably necrosed, for it has often been found necrosed in analogous cases.

(5) Finally, sacral eschars of neuropathic origin pretty often prove fatal by destroying the sacro-coccygeal ligament and thus opening the sacral canal, or by penetrating this canal in some other manner; whereupon there quickly supervenes either a *simple, purulent, ascending meningitis*, or a sort of *ichorous, ascending meningitis*. I have already mentioned a number of instances in which the sacral canal was opened by bed-sores with fatal effect. Mr. Hilton states that he has "several times seen fatal mischief result from a bed-sore extending to the interior of the vertebral canal, and causing inflammation of the spinal cord and its membranes."² He likewise presents an accurate drawing made from a preparation illustrating this important pathological condition, of which the accompanying wood-cut (Fig. 883) is a copy. This cut will remind surgeons of the close proximity of the spinal dura mater and the posterior wall of the sacral canal to bed-sores. *a, a, a.* A vertical section of the third, fourth, and fifth lumbar vertebræ. *b, b.* A vertical section of the sacrum. *d.* A portion of the sacral arch turned backward. *e, e.* Short, delicate, and elastic ligaments, seen proceeding from the lower part of the spinal dura mater to the sacrum. *c.* Dura mater, containing the cauda equina, spinal pia mater, and spinal arachnoid extending to a point opposite the second bone of the sacrum. Numerous strong ligaments are shown affixing the dura mater to the posterior ligament of the spinal column, opposite the second portion of the sacrum. Three distinct, slender ligaments proceed to the third, fourth, and fifth pieces of the sacrum. (Hilton.) The fact that the spinal membranes extend downward as far as the second piece of the sacrum, is well shown in the cut (Fig. 883). In one of Mr. Hilton's cases death resulted from pyæmia (pyæmic pneumonia), although the bed-sore had reached the interior of the vertebral canal, and involved the membranes of the spinal marrow.³

Fig. 883.



To illustrate the penetration of the sacral canal by bed-sores, and the occurrence of fatal spinal meningitis therefrom. (Hilton.)

Of the *ichorous form of ascending meningitis*, MM. Lisfranc and Baillarger have reported many remarkable examples. In this affection, it is found that a puriform, grayish, acrid, and fetid liquid steepes the spinal meninges and the cord itself; sometimes only the lower part, sometimes the whole cord is bathed in this liquid, which, occasionally, is also found

¹ New York Journal of Medicine, March, 1859, pp. 244, 245.

² Op. cit., pp. 213, 214.

³ Op. cit., p. 43.

at the base of the encephalon, as likewise in the fourth ventricle, in the aqueduct of Sylvius, and even in the lateral ventricles. At all these points in such cases, the cerebral substance is discolored on its surface and to a certain depth, acquiring a slaty-bluish tint, which is a product of imbibition, maceration, and dyeing. (Charcot.) When ichorous cerebral meningitis has a sacral bed-sore for its starting-point, the slaty hue, but more pronounced, is found over the whole extent of the spinal cord, and it grows more strongly marked as one approaches the bed-sore which has opened the sacral canal. Simple, purulent, ascending meningitis, however, is not attended with this peculiar discoloration; but it is unnecessary to dwell longer on this point, although it is by no means an unimportant one.

Pathogeny.—From the foregoing exposition of whatever facts are known concerning the variety of sphacelus in question (that is, concerning the acute sacral eschar, etc.), it is evident that the patient's position, or pressure, is never the chief cause of its production, and that in some cases pressure does not assist at all in originating it.

It also appears that its causation in no way depends upon paralysis of sensation and voluntary motion; for, in a case where the first lumbar vertebra was fractured (it is related on page 430), a sacral eschar appeared early and progressed steadily until it produced fatal exhaustion, although there was no paralysis whatever of sensation and voluntary motion. Other examples of similar import have likewise been mentioned in the foregoing pages.

Furthermore, it appears that the acute bed-sore does not arise from vaso-motor paralysis (that is, from paralysis of the bloodvessels); for, in the hemiparaplegia which ensues when one lateral half of the spinal cord is divided, the eschar never appears on the side of the sacrum, or in the lower extremity, where the vaso-motor paralysis is to be found, but on the side of the sacrum, or in the lower extremity, where vaso-motor paralysis does not exist. The inference is, of course, conclusive.

Finally, the kind of sphacelus in question does not result from the mere absence of nerve-action; for, in several cases of shot and other fractures of the vertebræ (related above), in which the spinal cord was partially or completely divided, no bed-sores appeared, although the patients survived their injuries several, and, in some instances, many days. The soldier whose vertebral fracture is represented by Fig. 871 (p. 371), survived a complete division of the spinal cord for twenty-nine days, and yet no bed-sore presented itself. Hutin's patient lived fourteen years—although the right half of the cauda equina had been divided by a small-arm missile near its commencement, the left half displaced by it, and its substance much disorganized—and ultimately died of Bright's disease. But examples almost without number can readily be adduced to show that the spinal cord may be divided, either partially or completely, without the supervention of bed-sores, however long the survival be protracted.

On the other hand, in perusing the cases of spinal injury where acute bed-sores, or analogous sphacelations, did appear, and where the condition of the cord revealed by post-mortem examination is described with sufficient minuteness, we generally find it distinctly stated, either that the cord was suffering from active mechanical irritation effected by the displaced and fractured vertebræ, or by the extravasation of blood, or that the cord-substance had undergone certain changes which we know result from the inflammatory process, or that the spinal membranes were inflamed. Thus, in the case of shot-fracture of the spinal column, represented by Fig. 870 (p. 371), in which the missile divided the spinal cord and lodged in the spinal canal opposite the fifth dorsal vertebra, a sacral eschar appeared; two weeks afterwards "sloughing of the

lower extremities" was noted; after another month, "sloughing extending" was part of the record made; and six weeks after that, death from exhaustion ensued. At the *autopsy* it was found, not only that the spinal cord was severed, and that the missile lay in the spinal canal, but also that the upper section of the spinal cord was "much softened," that is, exhibited a change which, under the circumstances, was doubtless inflammatory. Most of these particulars are taken from the Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 440, where the case is fully reported. Many similar instances have been mentioned in the foregoing pages, where acute sacral eschars or other sphacelations of an analogous character were attended with either an active mechanical irritation or a positive inflammation of the cord-substance, as was proved by post-mortem examination. On the whole, then, the dominant and ever-present fact in such cases is the active irritation of a more or less extensive region of the spinal cord, which mostly shows itself, anatomically, by the changes that characterize inflammation of the cord-substance (myelitis), and, clinically, by the outward phenomena or symptoms that arise from this lesion. Moreover, this conclusion is in strict conformity with the results of experiments on animals, which show that in them the development of gangrenous ulcerations over the sacrum does not supervene on ordinary sections of the cord, but only in cases where inflammation occurs in the cord-substance or membranes around the traumatic lesion. So much concerning the pathogeny of this most troublesome and destructive disorder appears certain.

But it is not probable that all the constituent parts of the spinal cord are equally liable, when excited by irritation or inflammation, to provoke the development of acute bed-sores. The great frequency of this accident in cases of hæmatomyelia, and of acute central myelitis, where the lesion occupies chiefly the central region of the spinal cord, seems to designate the gray substance as playing a predominant part in this respect. (Charcot.) This power is doubtless shared also by the posterior white fasciculi, for M. Charcot has shown that irritation of certain parts of these fasciculi has the effect of determining the production, not only of various cutaneous eruptions, but likewise of dermal necrosis with deep ulceration.¹

Furthermore, it is perfectly established that traumatism of the cauda equina, and other irritative lesions of the peripheral nerves, may give rise to an acute bed-sore, on the one hand, or to sphacelation of the integuments in their terminal areas, on the other hand. The illustrative examples presented above make this point quite clear; and there are many other examples on record. Perhaps, irritative lesions of the spinal ganglia of the nervi sympathici, too, may sometimes determine the rapid formation of eschars. But on this point we need more light to be thrown by clinical and pathological observations, as well as by experiments on animals.

Finally, in regard to the *essential lesion* of the spinal cord, of the cauda equina, or of the peripheral nerves in general, which determines the development of acute bed-sores and of other analogous sphacelations of the integument, we are still in the dark, at least as far as any positive knowledge of the subject is concerned. But, after all, it may in time yet be demonstrated that there really are *trophic nerves*, as Samuel has supposed, and that the pathological excitation of these nerve-filaments, whether it be effected in the spinal cord, or in the cauda equina, or in the trunks of other peripheral nerves, is attended by the formation of tegumentary eschars in the areas where the disordered nerve-filaments terminate, and over whose nutrition they preside.

¹ Op. cit., pp. 52, 73, 74.

Prognosis.—Neuropathic bed-sores, and neuropathic sphacelations in general, never bode any good. Still, they portend more of evil when they appear in the course of some affections, than they do when they appear in the course of others. For instance, a sacral eschar very seldom presents itself in a case of injury or disease of the brain which is to have a favorable termination; its appearance in such cases, therefore, constitutes a most inauspicious sign. We might in fact call it *sphacelus ominosus*, the *ominous* bed-sore, by way of distinction. (Charcot.¹) This accident, I repeat, rarely proves deceptive in cerebral injuries and diseases; and inasmuch as its existence may be discerned from its very incipency, it becomes of great value, especially in doubtful cases. The only prognostic sign that can at all rival it in cases of sudden hemiplegia, according to M. Charcot, is a very marked fall of the central temperature below the normal, occurring at the outset of an attack. Thus, the vesiculæ and bullæ which are the precursors of neuropathic sphacelus will, from their first appearance on the scene, enable us to form a prognosis with certainty in such instances.

But, in spinal injuries and diseases, recovery may yet take place after neuropathic bed-sores have appeared. Many such examples are on record, and almost every experienced surgeon has witnessed several. There are, however, certain phenomena which portend an unfavorable issue for the neuropathic sphacelations which result from spinal injury. These signs of impending evil are the following: (1) An early appearance of such sphacelations—that is, their occurrence before the pressure resulting from the patient's posture in bed has had sufficient time to share in their causation; (2) Their appearance in parts where pressure has had very little, or even no share at all, in their causation, as, for example, on the ankles, legs, inner surface of the thighs, etc.; (3) Their simultaneous appearance at several different points on both lower extremities; (4) Their very rapid enlargement on the one hand, or their steady enlargement in spite of treatment on the other; (5) The appearance of symptoms denoting that septicæmia, pyæmia, or ascending suppurative meningitis from penetration of the spinal canal, has occurred—a sign which usually denotes that the end is not far off. In a case reported by Mr. Hilton,² where a sacral eschar reached the interior of the vertebral canal and involved the membranes of the spinal marrow, pyæmia also supervened, and caused death in nine days. On *autopsy* the whole right lung was found pneumonic, with numerous, well-defined, small collections of pus in different parts of it.

Treatment.—The causal indications should be sought for and fulfilled as far as possible. To this end, in simple fractures and dislocations of the spinal column, reduction should be effected, for thus the risk of mechanical irritation of the spinal cord or its membranes, by the displaced vertebræ, will be more or less considerably lessened. In gunshot and other compound fractures of the spinal column, all foreign bodies should be removed from the wounds. In cases where spinal meningitis or myelitis is present and acting as the efficient cause of the bed-sores or sphacelations (and these cases form a numerous class), potassium iodide, ten grains three times a day, and fluid extract of ergot, one drachm three times a day, should be administered. When ergot has lost its effect, belladonna in rather large doses has sometimes been exhibited with benefit in cases of myelitis. But the chief internal remedies against spinal congestion, spinal meningitis, and spinal myelitis, are potassium iodide and ergot, and both drugs must, as a rule, be given in full or even excessive doses, to secure their good effects in these disorders. I advocate the trial of these

[¹ Charcot uses the term *decubitus ominosus*.]

² Op. cit., p. 213.

remedies in bed-sores and other sphacelations of spinal origin, not only on general principles, but also because, in several instances related in the foregoing pages, the good effects of these remedies were conspicuous in the rapid healing of the ulcers, and in the disappearance of the other spinal symptoms.

Although the pressure resulting from the patient's posture in bed is never the chief cause of neuropathic bed-sores, we should always endeavor to prevent its occurrence, or mitigate its effects, by placing the patient upon a water-bed, or by employing the various expedients which were mentioned in Vol. I. (p. 801); but, if possible, a water-bed should be obtained for such cases, because no expedient or combination of expedients will answer the purpose nearly as well. The integuments on the sacrum and nates should be kept dry and clean, that is, unsoiled with decomposing urine and feces; and these parts, in bed-ridden people, should be sponged over at least once a day with diluted alcohol or rectified spirit.

But when the eschar or sphacelus appears notwithstanding these measures, what more is to be done? The indication then is to limit the extent of the slough, as much as possible, by restoring or invigorating the circulation of blood in the affected parts. There are two procedures for fulfilling this indication, both of which possess great value. One of them was devised by M. Brown-Séquard, and I shall proceed to describe it in his own words:—

"I have tried," he says, "to prevent or cure those sloughs which are an evident result of the disturbance of nutrition due to an irritation of the nerves of bloodvessels, by acting upon the bloodvessels of the part where the sloughs exist. I have made experiments upon animals, showing that by applying alternately two poultices, one of pounded ice, the other a very warm bread or linseed poultice, there is a very rapid cure of the sloughs [when] due to a nervous irritation. Several medical men have already obtained the same results in man that I have obtained in animals, by following the plan of treatment that I have proposed. The pounded ice, kept in a bladder, is to be applied for eight or ten minutes, and the warm poultice for an hour or two, or even a longer period. . . . I think I can safely say that, in cases where a slough is beginning, its progress will always be stopped by the means I propose."

The other method is that of galvanism, which was first suggested and employed by Dr. Crussel, of St. Petersburg, and is as follows: A thin silver plate, no thicker than a sheet of paper, is to be cut so as to fit the exact size and shape of the bed-sore. A zinc plate of about the same size is connected with the silver plate by a fine silver or copper wire, six or eight inches in length. The silver plate is then placed in immediate contact with the bed-sore, and the zinc plate on some part of the skin above it—a piece of chamois-leather, soaked in vinegar, intervening, which, however, must be kept moist, or there will be little or no action of the battery. Within a few hours the beneficial effect becomes perceptible; and, in a day or two, the cure is in most cases complete. In a few instances a longer time is required. "I have frequently seen," Professor Wm. A. Hammond says,² "bed-sores three or four inches in diameter, and half an inch deep, heal entirely over in forty-eight hours." Mr. Spencer Wells states that he has often witnessed large ulcers covered by granulations within twenty-four hours, and completely filled up and cicatrization begun in forty-eight hours, under this treatment; and that it is the best of all methods for treating ulcers of indolent character, and bed-sores. Professor Hammond further states: "During the last twelve years I have employed it to a great extent in the treatment of bed-sores caused by disease of the spinal

¹ Lectures on the Physiology and Pathology of the Central Nervous System, etc., pp. 260, 261.

² Diseases of the Nervous System, 1881, p. 453.

cord, and with scarcely a failure—indeed, I may say without any failure except in two cases where deep sinuses had formed which could not be reached by the apparatus.”¹ If this plan of treatment should prove equally successful in other hands, a large share of the mortality which arises from spinal injuries may be avoided.

In the absence of ice, M. Brown-Séquard’s method may be employed by alternately applying to the bed-sores sponges, one of which is saturated with hot water and the other with cold water. This should be done several times every day, for five or ten minutes at a time; the effect is to increase the vascular activity of the part, and to promote granulation.

DISORDERS OF THE URINARY ORGANS ARISING FROM LESIONS OF THE SPINAL CORD.

Disorders of the urinary bladder, the ureters, and the kidneys, result from lesions of the spinal cord—from the so-called idiopathic, as well as from the traumatic affections of that organ—with even greater frequency than the bed-sores and other neuropathic sphacelations which have just been described; for, while the tegumentary eschars that arise from spinal lesions are always attended by more or less important disorders of the urinary organs, the latter not unfrequently present themselves in cases where the spinal cord is injured or diseased, without the fellowship of the former. Moreover, these urinary affections very often aid materially in producing death, and, not unfrequently, are the chief or even the sole proximate cause of a fatal issue, in such cases. These disorders, therefore, possess a degree of importance which is scarcely inferior to that of the neuropathic lesions of the integuments which have just been discussed; and they likewise should be attentively considered in this place.

The urinary affections that result from lesions of the spinal marrow are quite diversified, but may all be embraced and arranged under the following heads: (1) Paralysis of the bladder; (2) Alterations of the urinary secretion; (3) Inflammation of the kidneys, of the ureters, and of the bladder.

PARALYSIS OF THE BLADDER.—Inasmuch as the muscular apparatus belonging to the urinary bladder consists of two distinct parts, namely, (1) that which is employed to retain the urine in the organ, consisting of the *sphincter vesicæ* muscle, and (2) that which is used to expel the urinary secretion from the organ, consisting of the *detrusor urinæ* muscle; and, inasmuch as each of these muscles has a distinct reflex motor centre in the spinal cord, upon which its action or inaction depends, there are two distinct forms of vesical paralysis, one of which is manifested by *retention*, and the other by *incontinence* of urine.

The reflex motor centre of the *detrusor urinæ*, according to Dr. Bramwell,² is situated in the segments of the spinal cord which correspond to the 3d, 4th, and 5th sacral nerves, and the normally contracted state of the *sphincter vesicæ* is due to the action of a tonic centre which is situated in the segments of the cord corresponding to the 2d, 3d, and 4th sacral nerves. The reflex motor centres of these muscles are not only quite distinct in the anatomical sense, but they are likewise completely antagonistic in their motor action. The mechanism of normal micturition, then, appears to be as follows:

1. When the bladder becomes full enough, the sensory nerve-filaments in its

¹ Ibid., p. 453.

² Diseases of the Spinal Cord, pp. 117–119. New York. 1882.

mucous membrane are stimulated, and an impression is conveyed along the sensory nerves to the reflex centres for the detrusor and sphincter muscles in the spinal cord, and to the sensorium. 2. As a result of the sensory impression conveyed to the brain, the desire to urinate is experienced. 3. As a result of the impulse carried to the reflex motor centres in the spinal cord, the action of the detrusor centre is excited, while the action of the sphincter centre is inhibited. If the circumstances for urination be favorable, an impulse is sent from the brain by the will to the tonic centre for the sphincter, inhibiting its action, and causing the sphincter muscle to relax; also to the centre for the detrusor urinæ, strengthening the excitation of that muscle to contract, which has already been aroused by the reflex impulse from the bladder. In health, all these processes are simultaneously accomplished, and the result is micturition. When, however, the circumstances are not convenient for performing the act, it can be delayed or prevented (*a*) by voluntarily inhibiting the motor centre for the detrusor urinæ; (*b*) by causing the urethral muscles at the neck of the bladder to contract, likewise by an effort of the will; and, (*c*) possibly, by strengthening the tonic centre for the sphincter vesicæ, in the same manner, and at the same time. (Bramwell.) Thus it will be perceived that three distinct sets of nerves are always concerned in the act of voluntary micturition, namely, (1) a set by which the detrusor urinæ muscle is automatically operated; (2) a set by which the sphincter vesicæ is also operated automatically; and (3) the conducting fibres of the spinal cord through which the sentient being is enabled to perceive the need of micturating, and to send the mandate of the will down to micturate at once or to postpone the act, as circumstances may determine. Moreover, these physiological data can all be usefully employed in diagnosing the injuries and diseases of the spinal cord and spinal column.

There are two forms of *retention of urine* which arise from lesions of the spinal cord. In one of them, the conducting paths in the cord alone are at fault, for the reflex motor centres which determine the action of the vesical muscles are not affected. In such a case, the patient cannot micturate voluntarily, because the mandates of the will are not conveyed by the conducting fibres of the cord down to the motor centres for the vesical muscles. In such a case, too, the bladder will continue to empty itself automatically from time to time; that is, as soon as the quantity of urine collected in the viscus becomes sufficient to excite reflex contraction of the detrusor urinæ muscle, with inhibition of the sphincter muscle's tonic centre, evacuation of the viscus ensues. Examples of this form of urinary retention are not unfrequently afforded by lesions of the spinal cord occurring in the cervical or dorsal regions, when the nerve-injury is restricted to the site of the lesions themselves, and when, consequently, the reflex motor centres for the vesical muscles are unaffected. In such cases, the act of urination usually occurs without the patient's knowledge, as well as without his consent. In the other form of urinary retention, the difficulty arises from the fact that the reflex motor centre for the detrusor urinæ has ceased to act, while the tonic centre for the sphincter still continues to work, that is, from the fact that the detrusor muscle is paralyzed while the sphincter is not paralyzed. In examples of the first-mentioned form of urinary retention, catheterization may be unnecessary, and it is perhaps from his experience with this class of cases that Mr. Hutchinson¹ has been led to think that catheterization is unnecessary in all cases of spinal injury above the loins, unless vesical hyperæsthesia be also present. In the other form of urinary retention, however, that in which the detrusor muscle is paralyzed while the sphincter continues in a state of tonic

¹ London Hospital Reports, vol. iii. 1866.

contraction, catheterization performed at suitable intervals is always necessary, and must never be neglected; in fact, the operation is indispensable in such cases, for, if it be not performed, the urinary secretion will continue to accumulate in the viscus, until it becomes distended even to the point of bursting. I have myself seen more than one case, in civil as well as in military practice, of vesical paralysis arising from spinal injury, in which, from want of catheterization, the bladder became so much distended as to cause a notable tumefaction, discernible on external examination, and in which, on introducing a flexible instrument, a great quantity of urine, an ordinary chamber utensil more than half full, or considerably more than half a gallon, was withdrawn, and that, too, when there were no signs of urinary overflow present. Inasmuch as these two forms of urinary retention are clinically distinguishable from each other only by experimentally ascertaining whether reflex motor action can be excited in the detrusor muscle, the safest course for the surgeon to pursue, in both forms, is to draw off the water at suitable intervals with a perfectly clean, flexible instrument.

Incontinence of urine, when it results directly from injury or disease of the spinal cord, is always due to paralysis of the sphincter muscle, that is, to functional inactivity or destruction of the tonic centre in the cord upon which the contraction of its fibres, and the closure of the urethral orifice of the bladder, entirely depend. Paralysis of the sphincter vesicæ arising from destruction of its reflex centre, is almost invariably associated with paralysis of the detrusor urinæ, because its reflex centre is also destroyed. These reflex centres may be directly destroyed by injuries, *e. g.*, by fractures or dislocations of the lumbar vertebræ, or by hemorrhage into or inflammation of the cord-substance. But, as already intimated, paralysis of the sphincter vesicæ is very rare *per se*. It is nearly always accompanied by paralysis of the detrusor muscle, and by paralysis of the rectum.

Interruptions of the conducting parts to and from the brain, in the spinal cord above the reflex centres for the vesical muscles, are of frequent occurrence in spinal injuries. When the lesion of the cord is suddenly produced, it may be accompanied by a concussion of the cord which temporarily arrests the reflex motor functions of all the segments situated below the lesion, including of course the urinary centres. In chronic cases, the effect of the rachidian lesion varies with its position and extent. When the sensory conductors or sensory perceptive centres only are affected, the desire to urinate is not perceived; the reflex arc is uninjured, and, as soon as the bladder becomes sufficiently distended with urine, it is unconsciously evacuated. It, therefore, should be remembered that the involuntary discharge of urine and feces, in cases of paraplegia or coma, does not necessarily imply any paralysis of the bladder or rectum.

When the motor and inhibitory conducting fibres of the cord alone are interrupted, the desire to urinate is perceived, but the act itself takes place quite independently of volition. It can neither be assisted nor deferred by any effort of the will in such cases.

Concussion of the spinal cord, especially when the lower part of it alone is affected, may be attended by paralysis of the detrusor muscle, indicated by retention of urine, when no other portion of the muscular system appears to be paralyzed.

Concussion of the spinal cord, when severe enough to produce paraplegia (that is, both voluntary-motor and sensory paralysis in the lower part of the body), may also suppress for a time the reflex motor functions of the urinary centres, as well as the conducting functions of the rachidian fibres; and then paralysis of the sphincter muscle, with incontinence of urine, will also be present.

Congestion of the spinal cord coming on some days, it may be, after falls or blows upon the lower part of the spinal column, sometimes causes paralysis of the detrusor muscle, with retention of urine, when no such paralysis followed the injury.

Myelitis causes incontinence of urine because it destroys the tonic centre for the sphincter vesicæ, and thus paralyzes that muscle, as well as the sphincter ani, etc.

ALTERATIONS OF THE URINARY SECRETION very often arise from injuries and diseases of the spinal cord. Briefly stated, these alterations consist of alkalinity, which is often excessive; of the presence of an abnormally great quantity of the phosphates; and of the existence, in the urine, of blood, pus, and mucus. Occasionally the urinary secretion is entirely suppressed in such instances.

It has long been noticed by surgeons that, after fractures of the vertebral column with consecutive lesions of the spinal cord, the composition of the urine very frequently and very rapidly becomes altered. In almost all cases of traumatic myelitis, it soon presents a remarkable alkalinity. I have also reported two cases of spinal injury with marked displacement between the fifth and seventh cervical vertebrae, and paraplegia, in which it was observed on the second day after the accident that the urine when withdrawn by catheterization had a strongly ammoniacal odor, that is, was strongly alkaline, although that operation had been thoroughly performed as often as needful ever since the accidents. A great many cases have likewise been mentioned in the foregoing pages, in which, soon after the reception of spinal injuries, the urinary secretion was found to be alkaline instead of acid. Sir B. C. Brodie¹ especially called attention to the characteristics presented by the urine in the case of persons stricken with traumatic paraplegia. He observed the urine to be alkaline, and to exhale a fetid, ammoniacal odor at the moment of emission, on the second, on the third, and on the eighth day. Soon afterward, this secretion contained blood-clots, muco-purulent matter, and deposits of ammoniaco-magnesian phosphates. It would be easy to collect from authors of repute a very great number of analogous cases. I shall mention but two additional observations.

Dupuytren pointed out that, in cases of spinal fracture with lesion of the cord, the catheter when allowed to remain in order to guard against retention quickly became coated with a calcareous incrustation.

Mr. Shaw² relates the case of a young man who had fracture of a dorsal vertebra and complete paraplegia, caused by falling from a tree. Extensive sloughs formed on the nates, but they healed, and he appeared to be recovering with paralysis, after surviving eight months. During most of this time his water flowed continuously into a urinal, and the catheter was not used. Eventually, however, his urine became turbid and fetid; and he died with symptoms of aggravated disease of the bladder. The *autopsy* revealed a discolored and shreddy state of the vesical mucous membrane, with five phosphatic calculi as large as pigeons' eggs, and coated with mucus, in the bladder; also phosphatic calculi were found impacted in the calices, and lying loose in the pelvis, of each kidney.

The alkaline and phosphatic characters of the urine are met with in lesions of the spinal cord so constantly, that their presence must be mainly due to the operation of some single cause which acts efficiently in nearly all the cases. Some hold that this condition of the urine is caused principally by the introduction of septic matters from without into the bladder. But this

¹ Medico-Chirurgical Transactions, 1836, p. 148.

² Holmes's System of Surgery, vol. ii. p. 401, 2d ed.

explanation utterly fails to account for a numerous class of cases in which no catheters excepting those perfectly free from septic matters are employed, or in which the urine is found to be ammoniacal and phosphatic on the very first occasion that the catheter is introduced, or in which catheterization is not employed at all from first to last, and still the urine is ammoniacal and phosphatic. Moreover, the use of catheters, and bougies, and sounds is a common thing in the practice of surgery, and yet no such effects appear in any other class of cases. I have no doubt that these effects mainly arise from neurotrophic or neuropathic disturbance of the kidneys and bladder, as was originally pointed out by M. Brown-Séquard. The sanguinolent or muco-purulent qualities of the urine, in such cases, result directly from congestion or inflammation of the kidneys and bladder. I have also seen some cases belonging to this category in which the quantity of the urinary secretion was much increased above the normal.

Finally, excess of phosphates occurs in many cases of cord-disease, independently of bladder-paralysis (as is generally known and admitted); I, therefore, claim that the neutral or alkaline condition of the urinary secretion, with its remarkable proneness to speedily decompose, which is often witnessed in the same, as well as in analogous cases, also occurs independently of bladder-paralysis, and, like the former, results from the rachidian lesion, in consequence of the disturbance it effects in the working of the kidneys. In this way alone can be satisfactorily explained the strongly ammoniacal odor perceived at the moment of emission, in urine that contains neither mucus nor pus, which I have observed in at least one instance of traumatic paraplegia arising from displacement of the lower cervical vertebræ, in less than thirty hours after the accident, when the subject (a man) was previously in perfect health, and when it was not possible for the kidneys or bladder to have sustained any direct injury. The urinary secretion became abnormal in this case, in consequence of the morbid excitation of the spinal cord which was produced by the injury.

INFLAMMATION OF THE URINARY ORGANS.—As we have seen that important alterations of the urinary secretion very often result from injuries and diseases of the spinal cord, and as we have found that acute bed-sores and other neuropathic sphacelations of the integuments not unfrequently arise from the same causes, so also we shall find that inflammation of the kidneys, and of the ureters, and of the bladder, or rather of the mucous membrane which lines these organs, often has an identical origin.

This form of renal and vesical inflammation is a very important disorder, because (1) it gives much trouble to patients and their attendants, and (2) it very often proves fatal; for, as Mr. Bryant justly remarks, when death occurs as a result of injury to the dorsal region of the spine, suppuration of the kidneys, cystitis, and bed-sores, are the most common proximate causes thereof.¹

M. Brown-Séquard first called attention to the neuropathic origin of this highly destructive form of renal and vesical inflammation. In 1858, he said :—

“Another morbid change due to a mechanical excitation of the spinal cord may cause death after a fracture of the spine; it is the alteration which takes place in the kidneys [and bladder], an alteration sometimes amounting to a real inflammation. We hardly need to say that the changes in the urinary secretion, owing or not to an inflammation of the kidneys, also the hæmaturia, and the alterations in the mucous membrane of the bladder, in cases of fracture of the spine, are morbid phenomena depending upon

¹ Op. cit., p. 202.

an irritation of the spinal cord, and not upon a paralysis due to a division of the cord. For on the one hand, a [mere] section of the cord is never followed by these alterations in the kidneys or the bladder; and, on the other hand, we often observe these alterations too quickly after the spine has been fractured, to admit that they are due to a paralysis."¹

In the same lecture he also said:—

"The influence of a mechanical excitation of the spinal cord by a piece of broken bone [or of a pathological excitation of the cord by an inflammatory process], deserves the full attention of the physiologist and the practitioner. Among the alterations of nutrition, . . . in cases of that kind, we will particularly notice the sloughs on the sacrum, and the various morbid changes that take place in the bladder and in the urinary secretion. These alterations in nutrition and secretion are certainly frequent causes of death after fractures of the spine. Therefore, it is of the greatest importance to find out the mode of production of these morbid changes, and to try to prevent or to cure them."²

The mode of *causation*, as well as the *phenomena* of the renal and vesical inflammations which result from lesions of the spinal cord, can be most briefly, as well as clearly set forth, by presenting a few examples; and a very instructive one has already been mentioned on page 343:—

A young infantry soldier, aged 19, fractured his fifth cervical vertebra, without displacement, while bathing in the Arkansas River, by diving headforemost into shallow water, and immediately became paraplegic from concussion of the spinal cord. Intrathecal extravasation of blood ensued, and, on the following day, the cord showed signs of compression arising from this cause. But absorption of the extravasated blood occurred, the symptoms of paraplegia gradually passed away, and in eight days he became able to pass his urine without a catheter. He continued to improve during the next four or five days, until traumatic spinal meningitis rather suddenly supervened, its invasion being marked by chills and by a rise in the body-heat. Myelitis followed. In two or three days alterations in the urinary secretions began to appear. I will now quote the words of the official report: "On the morning of the 18th, the urine became turbid." "By the morning of the 20th, the pulse had become so frequent that it could not be counted, the bowels were loose, the urine was ammoniacal and thick with mucus." "A very high temperature (105°) followed. The patient at this time was still able to pass his urine without a catheter; but [hæmaturia supervened and], on the 21st, this instrument was used with difficulty, owing to the formation of clots in the bladder. The patient also suffered from decubitus [bed-sores], and, by the 24th, his stomach became so irritable as to retain scarcely anything. On the day following his appetite was entirely gone. On the 26th the temperature was 91.8°. He died at noon on the 28th," twenty-five days after the accident, and ten or twelve days after his urine first began to be abnormal. The *autopsy* revealed the following urinary lesions: "The kidneys were enlarged and gorged with blood; the pelvis of the left being filled with pus." "The ureters were very dark, and one of them contained a clot at the entrance of the bladder. The walls of the bladder were of a dark-purple color, inflamed, and thickened; the mucous membrane being absent in patches."³

The urinary lesions in this case did not arise from injury (traumatism) of the kidneys or bladder, for the urinary discharge did not present any morbid appearances until a fortnight after the accident; they were not due to paralysis of the bladder, for the urinary paralysis had disappeared, and the man had passed his water at will for a week before it presented any abnormal change; they were not caused by the introduction of septic matters from without, because catheterization had been discontinued for a week before "the urine became turbid," and was not again resorted to until three days afterward, when hæmaturia had occurred, and the urethral outlet of the bladder

¹ Op. cit., p. 249.

² Ibid., p. 248.

³ Circular No. 3, S. G. O., August 17, 1871, pp. 125-131.

had become choked with coagula. There remains, then, no appreciable or perceptible cause whatever for the remarkably inflamed state of the kidneys, ureters, and bladder, which the autopsy revealed in this case, excepting the excitation of the spinal cord by the secondary meningitis and myelitis, which had supervened two or three days before the urinary secretion "became turbid." Thus, it is shown that the urinary lesions in this case had a neuropathic source. Moreover, an acute bed-sore—that is, a neuropathic eschar—presented itself, at the same time, over the sacrum, in this patient; this circumstance also affords presumptive evidence that the urinary lesions had a similar origin.

The urinary lesions appear to have been the chief proximate cause of this patient's death, which occurred about ten days after the signs of these lesions first became visible. This neuropathic nephritis and cystitis, etc., therefore, ran a remarkably rapid course, and quickly proved fatal. The symptoms presented themselves in the following order: On the first day, it was observed that the urinary discharge was "turbid;" no doubt it was also ammoniacal. Two days afterward, it was remarked that the urinary discharge was highly "ammoniacal and thick with mucus," that the "bowels were loose," and that great prostration with "a very high temperature (105°)" was also present. After still another day, hæmaturia supervened, and the urethral outlet of the bladder becoming plugged with clotted blood, it was necessary to introduce a catheter. On the same day it was noted in the clinical history that the patient was also suffering from bed-sores. In three days more there was extreme anorexia, with very great gastric irritability; and in four days after that death ensued. This *peracute* inflammation of the urinary organs wrought the following structural changes: The kidneys were intensely hyperæmic, and therefore enlarged, while the pelvis of the left one was filled with purulent matter. The coats of the bladder were intensely inflamed, dark-purple in color, and thickened; its mucous membrane had also sloughed off in patches. The ureters, likewise, were very dark in color and intensely inflamed. In consequence of these structural changes, the urinary secretion speedily became loaded with muco-purulent matter and blood. The hæmaturia which occurred during life was obviously caused by the rupture of the over-distended blood-vessels of the kidneys, etc. No wonder, then, that general prostration of an extreme character should rapidly come on in such a case of renal and cystic inflammation, and that death should speedily ensue.

Another highly instructive example of neuropathic inflammation of the kidneys, ureters, and bladder, has likewise been mentioned in these pages already (p. 414); but it is well worth further study, and I shall therefore speak of it again. It was originally recorded by Sir W. Gull:—

A man, aged 25, contracted acute myelitis of the dorsal region in consequence of straining his back in lifting a heavy weight. No bones nor ligaments, however, were injured. On the morning of the second day after the accident he found himself paralytic on walking, in consequence of the rachidian inflammation. On the fourth day after the injury he was admitted into Guy's Hospital. There was already complete paraplegia, together with a sacral eschar; and ammoniacal urine constantly dribbled from his paralyzed bladder. Forty-one days after the accident, or thirty-seven days after entering the hospital, he died. At the *autopsy*, commencing supuration in the cortical substance of the kidneys was noted. The mucous membrane of their pelves was greenish in color, with patches of greenish-colored fibrinous exudation thereon. The mucous membrane of the ureters and bladder was in the same condition. The bladder contained a quantity of muco-purulent fluid. The substance of the spinal cord was changed into a thick, greenish, muco-puriform liquid throughout its entire thickness, opposite the fifth and sixth dorsal vertebræ, while the cervical and lumbar portions of the cord were unchanged.

Is there any room for doubt in regard to the etiology of the renal and vesical inflammation which the autopsy revealed in this case? Can the origin of this inflammation be assigned with propriety to any cause, excepting the extremely well-marked myelitis, and the morbid excitation of the spinal cord which it occasioned? It cannot be ascribed to the introduction of septic matters from without, because there is no evidence nor probability that a catheter was ever used in this case; and it does not appear that any necessity ever existed for using a catheter on this man, inasmuch as his urine is known to have been discharged by dribbling (from paralysis of the sphincter vesicæ) almost from the outset, and probably was discharged in this manner from the very outset of the case. Moreover, an acute bed-sore of large size presented itself in the sacro-gluteal region, and this, together with the urinary lesions, destroyed the man's life; and, as the sacral eschar had a neuropathic origin, even so the urinary lesions had the same origin.

Although the inflammatory process in the urinary organs was much less acute in this than it was in the preceding example, the textural changes produced by it, and revealed by the autopsy, were quite well marked. They were as follows: Suppuration in the cortical portion of the kidneys; inflammatory discoloration, and, no doubt, thickening of the mucous membrane lining the renal pelves, the ureters, and the bladder; also greenish-colored fibrinous exudation collected in patches on every part of this membrane. The greenish hue of the exudation, as well as of the inflamed mucous membrane itself, was due to staining with the red corpuscles of the blood; hæmaturia had doubtless supervened some time before death. Finally, the urinary bladder contained a quantity of muco-purulent liquid, the muco-purulent elements of which had been produced by the inflammatory process.

Many other examples belonging to the same category have been presented in the foregoing pages. Should, however, additional evidence be required in regard to the etiology of the urinary disorders under consideration, it may readily be found in M. Charcot's Lectures, already so often quoted: evidence which, although weighty and convincing, cannot be reproduced here for want of room.

To briefly summarize the *symptoms* which usually attend the neuropathic inflammations of the urinary organs that very frequently supervene in cases of spinal injury: Soon after the accident, that is, within a period beginning on the second, and ending about the ninth day thereafter, it is observed that the urine, previously acid and clear, or perfectly normal, suddenly becomes alkaline, and exhales a pungent ammoniacal smell at the moment of emission. Shortly afterward, it is noticed that the urinary discharge has a cloudy and turbid look, arising from the admixture of mucus, as well as a strongly ammoniacal odor. The quantity of this mucus gradually increases until the urinary discharge becomes ropy, tenacious, and so thick from this cause that it even adheres to the bottom of the vessel. In a short time, a white substance—the phosphate of lime—is found mixed with the mucus. Pus-corpuscles and blood-disks also present themselves. The quantity of the former may be so great as to cause a muco-purulent appearance. Oftentimes, the blood-disks present themselves in such large number as to constitute a veritable hemorrhage from the urinary organs, technically denominated hæmaturia. But blood-disks will often be seen with a microscope, when to the unaided eye the urinary discharge does not present a sanguinolent appearance. In the chronic cases, and near the end of most of the fatal cases, the urinary discharge consists apparently of a muco-purulent liquid, in which, however, blood-corpuscles or their remains are almost always found by microscopical examination, intermingled with pus-cells and renal and vesical epithelium, that is, muco-pus, with vibriones and phosphates, etc.

To epitomize the *anatomical lesions* which usually accompany the neuropathic inflammations of the urinary organs that occur in cases of spinal injury: They are hyperæmia, more or less intense, according to the case, with tumefaction and dark-red or purple discoloration of the mucous membrane lining the kidneys, the ureters, and the bladder; intense hyperæmia with tumefaction of the renal parenchyma, and of the walls of the ureters and bladder; fibrinous exudation in patches on the mucous membrane lining these organs; extravasated blood in both a fluid and coagulated state in the pelves of the kidneys, the canals of the ureters, and the cavity of the bladder; suppuration of the secreting portions of the kidneys, and abscess of their pelves; inflammatory thickening of the coats of the bladder and ureters, with softening and erosions of their lining or mucous membrane. In such cases, patches of the mucous membrane are apt to be cast off as sloughs, and the inflammatory process, being violent, generally involves also or extends to the other tunics of the bladder and ureters, as well as to the parenchyma of the kidneys: As a rule, the inflammatory process in such cases does not appear to start in the bladder and spread thence into the kidneys, nor *vice versa*; but it is simultaneously kindled in all parts of the mucous membrane belonging to the kidneys, ureters, and bladder. In chronic cases, phosphatic calculi form in the kidneys, as well as in the bladder, and in either place they may set up fatal irritation.

Thus, it will be perceived that the inflammatory process which is set up in the mucous membrane of the urinary organs by certain morbid excitations of the spinal cord, bears, at least "in the acute" instances, no inconsiderable resemblance to the necrotic processes which are set up in the integuments by the operation of the same causes. The destructive process in both is characterized by intense, dark-colored hyperæmia, extravasation of blood from ruptured capillaries, and sloughing of the tissues involved. In the less severe or chronic cases, the urinary mucous membrane exhibits pathological changes quite analogous to the cutaneous erythema and other diffuse phlogoses of the integuments which are caused by similar lesions of the spinal cord, that have been described above.

Furthermore, it is highly probable that when the urinary secretion comes into contact with the inflamed mucous membrane of the bladder, ureters, etc., it suffers decomposition in consequence of such contact, just as happens in ordinary cystitis; by which decomposition it acquires highly irritating properties that in turn may react upon the already inflamed mucous membrane, and augment its disorder. The urine rots while lying in the bladder, in such cases, not because the walls of the bladder may chance to be paralyzed at the time, as Mr. Shaw and others have vainly asserted, but because it there becomes tainted with the products of the inflammatory process which is going on in the bladder, the ureters, and the kidneys. This statement is fully borne out by what occurred in the *peracute* example just now related—the example in which a young soldier had sustained fracture without displacement of the fifth cervical vertebra in consequence of diving headforemost into shallow water: on the fifteenth day after the accident, there supervened a neuropathic inflammation of his kidneys, ureters, and bladder, which caused death in ten days, although he had been able to pass his water at will for a week previously (which proves that the bladder-paralysis had been absent for a week), and although it was not necessary to use a catheter on him again until three days after the urinary disorder had appeared, and then the instrument was introduced, not because the bladder was paralyzed, but because its urethral orifice was choked with blood-clot arising from hæmaturia. Moreover, to say that in such a case the rotting urine produced an inflammation of the

bladder which subsequently spread to the kidneys, would be to blindly put the effect in the place of the cause, and perhaps lead to erroneous practice.

Treatment.—From the foregoing account of the urinary lesions that result from certain morbid excitations of the spinal cord, it is obvious that any plan of treatment which does not fulfil the causal indications—which does not put to rest the agencies that create these sad lesions—cannot do much good in such cases. I have thus patiently and thoroughly inquired into the etiology of these disorders with no purpose to dig up and exhibit any pathological curiosities; but, rather, in doing this I have been moved by a strong desire to devise, if possible, some plan of treatment which shall prevent and perhaps even cure these deplorable lesions. And, inasmuch as they generally arise from congestion or inflammation of the spinal cord, or of its membranes, or are greatly augmented by these affections of the central nervous system, the first indication to be fulfilled in treating the neuropathic lesions of the urinary organs, is to subdue the central nervous affections upon which their existence depends. To this end I recommend the administration *per os* of fluid extract of ergot, of potassium iodide, and of belladonna, in the doses and in the manner already laid down in describing the treatment of neuropathic bed-sores (page 434), which it is not necessary to repeat in this place. All other means of fulfilling the causal indications which are there mentioned should be employed in these cases also; and less inconvenience will be experienced in carrying out this treatment from the fact that when these neuropathic disorders of the urinary organs make their appearance, neuropathic bed-sores almost always present themselves at the same time. In regard to the results of this plan of treatment, I find, on a reperusal of some cases in which it was advantageously employed for bed-sores, that it proved equally useful for the accompanying urinary lesions. Belladonna plasters, applied over the kidneys, may do good in all such cases.

The urine, as a rule, being strongly ammoniacal and therefore very pungent, should not be allowed to stand in the inflamed bladder, and in the case of any paralytics who cannot void it at will, or from whom it does not flow spontaneously, it should be withdrawn by catheterization as often at least as every four or six hours; but, at the same time, every precaution must be taken, by using only a perfectly clean instrument, etc., to prevent entirely the introduction of septic matter into the bladder.

Hæmaturia often occurs in consequence of neuropathic inflammation of the kidneys, ureters, and bladder. When it proves dangerous or troublesome, it should be treated on the plan already prescribed for traumatic hæmaturia (page 298 *supra*), which it is unnecessary here to repeat. It will, however, be necessary to break down and wash out the coagula by injecting warm water medicated with boracic acid through a large-sized catheter, more frequently in these than in the traumatic cases.

The sloughs falling from the inflamed mucous membrane, with the mucopurulent and phosphatic, or mortar-like matter that may collect in the bladder in such cases, should likewise be washed out by injecting warm water impregnated with boracic acid through a double catheter.

TYMPANITES ARISING FROM LESIONS OF THE SPINAL CORD.

All lesions of the spinal column or spinal cord that cause paraplegia, may be attended by distension of the abdomen with gaseous substances which are generated and held in the abdominal portion of the alimentary canal, that is, in the stomach, and in the small, as well as in the large intestines; their most common seat, however, being the arch and sigmoid flexure of the

colon. In such cases, the distended belly is tense and elastic; and, on percussion, it sounds like a huge bladder or a drum filled with air. This kind of abdominal tumefaction has with much propriety been called *tympanites*, because, when struck, it sounds like a drum. The intestinal gases accumulate within the digestive tube in such cases, because the muscular wall of the abdomen and the muscular coat of the intestines, being paralyzed in consequence of the spinal lesion, are no longer able to contract and thus expel them; and since, through loss of contractility, the abdominal and intestinal muscles can offer no effective resistance to the accumulation of these gases, it often goes on until the abdominal distension becomes enormous. The tympanites in such cases is symptomatic of the spinal lesion; and, when enormous or even very considerable in degree, it is usually a fatal sign.

But tympanites always tends in such cases to embarrass the patient's breathing by opposing the descent of the diaphragm during the inspiratory movement; and, when it is very considerable, it causes corresponding dyspnoea. It is, however, in those cases of spinal injury where the paraplegia extends up to the root of the neck—those cases wherein the respiratory movements are performed by the diaphragm alone, and where consequently the respiration is said to be diaphragmatic or abdominal—it is in such cases that tympanites does the most harm, and often aids with no inconsiderable force in shortening life, by increasing the difficulty of breathing, which perhaps is already very great. Many cases have been mentioned or referred to above, in which this very thing occurred. But probably the most notable example was presented on page 410. The case was that of a cavalry soldier, who in a brawl received a shot-wound of the neck, which fractured the spinous process of the last cervical and the laminae of the first dorsal vertebra, opened the spinal canal, ruptured the theca vertebralis, and drove several small fragments of bone into the substance of the spinal cord. In this case, "the paralysis of the abdominal and intestinal muscles allowed an accumulation of gases to take place within the intestines, to such an extent as greatly to augment the already existing difficulty of respiration. It was found expedient to introduce an elastic tube, from time to time, through which the gases found vent, when pressure was made, externally, on the abdomen."¹ Tympanites, therefore, not unfrequently constitutes in cases of spinal injury a complication which urgently demands the surgeon's attention.

Treatment.—The kind of tympanites in question is always symptomatic of some affection of the spinal cord which, as a rule, interrupts its reflex-motor, as well as its conducting functions. The nature of this central nervous affection should be ascertained, and, if possible, the disease itself should be removed; which can often be done, if it consist in concussion, congestion, or one of the less severe types of inflammation of the spinal cord or its membranes, by carrying out the corresponding plans of treatment which have already been laid down in these pages.

When immediate relief from the tympanitic distension is urgently demanded, it has been proposed by some surgeons to resort to the operation of *paracentesis*, performed on the descending colon with a long narrow trocar and canula; but, inasmuch as this operation is never, in my opinion, justifiable, I shall not take space to describe the steps that pertain to it. The best way to let the wind out in such cases is by introducing a flexible tube of suitable size and length, through the anus and rectum into the sigmoid flexure of the colon, as was originally done, I believe, with success in analogous cases, by Dr. O'Beirne, who used an œsophagus tube for the purpose—a method which likewise was successfully employed in the case just related.

¹ Circular No. 3, S. G. O., August 17, 1871, pp. 21, 22.

Should it be necessary to discharge the wind from the stomach, or from the small intestines, by an operation, it might be done with comparative safety by aspiration.

Antispasmodics and carminatives, æther, ol. anisi, assafoetida, tinct. cardamomi, tinct. zingiberi, tinct. rhei, or ol. terebinthinæ, will of course be administered, by the mouth or by the rectum, in these cases; and warm purgative medicines, and warm purgative clysters, should likewise be employed.

PRIAPISM IN CONSEQUENCE OF SPINAL INJURIES.

The term priapism is here used to signify a more or less complete erection of the penis (but most often it is incomplete), which is unattended by voluptuous sensations, and which is caused by injury or disease of the spinal cord, instead of by sexual desire or normal excitation.

This condition of the penis is very often observed in cases of spinal injury. It will therefore be instructive, as well as interesting, to consider briefly the clinical relations, the etiology, and the import or signification of this disorder of the male sexual organs.

Phenomena of Priapism.—Priapism is usually described as a mere “turgescence,” or bare “stiffness” of the penis, which does not amount to an erection in the true sense of the term. For it is commonly observed in priapism, that while the “turgescence,” or “stiffness,” does not attain the rigidity of a true erection, it likewise does not cause the head of the penis to rise upward beyond a line drawn perpendicularly to the long axis of the body. Moreover, the penis does not of necessity become increased in length and breadth, or diameter, in priapism, as it does in normal erection, or in that state of the organ which renders it capable of intromission; for I have observed at least one case of vertebral injury in which the penis, although in a state of undoubted priapism that lasted as long as life continued, measured only one inch and a half in length; while after death, when complete relaxation had taken place, it measured two and one-half inches in length. But the foregoing description does not embrace the phenomena that are witnessed in all the cases of priapism arising from spinal injury; for while this description holds good in most cases, there are at least occasional instances of spinal injury in which the priapism amounts to a “strong erection,” as was observed in an example already presented for another purpose on page 423. The case, in brief, was that of a stableman, aged 30, having transverse fracture with dislocation of the seventh cervical vertebra, caused by falling down stairs, who was admitted into Bellevue Hospital twenty-three hours after the accident, with complete sensory and voluntary motor paralysis of the lower extremities and trunk up to the third or fourth ribs; also diaphragmatic breathing, retention of urine, etc., and, at the same time, “the penis was strongly erected.” This state of vigorous erection must, in great measure, have subsided not very long after admission, for on the third day this entry was made in the clinical record of the case: “priapism always induced by passing the catheter.” That night the man died of asphyxia, caused by traumatic, ascending myelitis. Thus it appears that the clinical phenomena of priapism may vary in different cases, or in different periods of the same case, from those of bare turgidity or slight stiffness of the penis, on the one hand, through all the ascending grades of turgidity and stiffness up to strong erections of the organ, on the other.

Another erroneous statement in regard to priapism is frequently made, namely, that it occurs only in cases where the cervical or the upper dorsal vertebræ are fractured or dislocated. But the truth is, that it is also met with not unfrequently in cases where the middle dorsal, or the lower dorsal, or the

upper lumbar vertebræ are fractured or dislocated. For instance, I have already related for another purpose, on page 390, the case of a derrick-man, aged 41, who had his tenth dorsal vertebra fractured by being thrown from a cart, and was admitted into Bellevue Hospital two hours after the accident, in a state of profound collapse, with the pulse too frequent and feeble to be counted, and with the lower extremities and body completely paralyzed as to sensation and voluntary motion up to the sixth intercostal space; still, there was moderate priapism observed. I have likewise already mentioned, on page 375, the case of an officer, which was originally reported by Surgeon C. S. Tripler, U. S. Army, and in which there was a shot-fracture of the spinal column at the junction of the dorsal and lumbar regions, attended with paraplegia, retention of urine and feces, and priapism. Furthermore, I have mentioned, on page 337, the case of a man, aged 25 (it was related by Dr. Parker), who sustained a dislocation of the twelfth dorsal upon the first lumbar vertebra, with slight fracture, in consequence of being struck by a falling door, and who had priapism as well as paraplegia; and, no doubt, in several other instances of inferior dorsal or lumbar fractures or dislocations of the vertebræ that are related or referred to above, there was priapism as well as paraplegia present.

In addition to these observations, I will take space only to mention a case reported by Dr. Hutchison,¹ of Brooklyn, N. Y., in which the eighth, ninth, tenth, and eleventh dorsal vertebræ were fractured, in a man, aged 35, by falling fifteen feet from a scaffold, and in which paralysis, priapism, etc., ensued; another case reported by MM. A. Pousson and F. Lalesque,² in which a man, aged 40, sustained dislocation of the eleventh dorsal vertebra combined with fracture of its laminae, and in which, besides paraplegia, there were priapism, etc.; and a third case recorded by Mr. Hilton,³ in which a man, aged 30, fell through a trap-door, sixteen or eighteen feet, fractured his eleventh dorsal vertebra, and completely divided his spinal cord, with the effect of producing complete paraplegia, etc., as well as priapism, which appeared, however, on the second day. I have no doubt that if a search were specially instituted for the purpose, a considerable number of additional cases could be collected in which fractures or dislocations of the vertebræ in the lower dorsal and lumbar regions were attended by priapism, as well as by paralysis. This peculiar disorder of the male genitalia is, however, met with much more frequently in the cervical and upper dorsal regions than elsewhere, but it should also be borne in mind that fractures and dislocations of the vertebræ occur much the most frequently in these regions.

It may be of interest to remark, in this connection, that Professor Agnew states that he has seen priapism present itself after injuries of the head,⁴ as well as after those of the spinal column.

But priapism may likewise appear in cases of *concussion* or *contusion* of the spinal cord, and in consequence of those injuries. I have already presented two examples belonging to this category on pages 384 and 386; one of these was reported by Sir W. Gull, and the other by Mr. Savory. In Sir W. Gull's case, the only lesions of the cord observable were ecchymosis and hyperæmia, mostly in the gray substance, opposite the fourth and fifth cervical vertebræ. The priapism disappeared in a few hours, but returned on the following day. In Mr. Savory's case, there was complete loss of sensation and voluntary motion in the lower extremities, and in the trunk nearly

¹ American Medical Times, 1861.

² Medical News and Abstract, March, 1881, pp. 179, 180.

³ Guy's Hospital Reports, 3d series, vol. xi.

⁴ Principles and Practice of Surgery, vol. i. p. 829.

up to the clavicles, the respiration was entirely diaphragmatic, and no reflex action could be excited in the lower extremities or elsewhere; still there was partial priapism. Death occurred in thirty hours; and the autopsy showed a clot of blood in the substance of the cord opposite the fourth cervical vertebra.

Furthermore, priapism may be caused by *inflammation* of the spinal cord. There was a marked degree of priapism observed in a case of acute and very extensive myelitis, terminating fatally in ten or twelve days, that was recorded by Dr. C. B. Radcliffe.¹ Motor and sensory paralysis extended up to a line drawn around the body four inches below the ensiform cartilage. Reflex movements were also absent, but there was retention of urine.² Priapism may be an important indication that myelitis is present. Dr. Hammond enumerates among the symptoms of acute myelitis frequent and almost constant erections.³ Dr. Bramwell in describing the symptoms of acute myelitis states that priapism is often present among them.⁴ In Mr. Hilton's case, mentioned above, the priapism which supervened on the second day after the accident probably arose from inflammation of the cord-substance. Thus, we have shown that priapism not unfrequently occurs in cases of concussion, contusion, and inflammation of the spinal cord, as well as in cases of fracture and dislocation of the spinal column; the conclusion to be drawn therefrom is irresistible that the *essential lesion*, or the peculiar pathological condition upon which the occurrence of priapism depends, is seated in the spinal cord, and not in the spinal column nor in the exterior parts.

What is the *essential lesion*? what the physiological apparatus from the disorder of which priapism arises? The fact that the location or site of the essential lesion must be sought for in the spinal cord itself, at once disposes of the theory which ascribes the causation of priapism to lesions of the cervical or dorsal ganglia of the nervi sympathici which lie along the spinal column. It, however, does not dispose of another theory which ascribes the cause of priapism to lesions of those filaments of the nervi sympathici which exist in the spinal cord, and to vaso-motor paralysis of the bloodvessels arising therefrom. Professor Agnew seems inclined to adopt this theory, for he says: "These erections of the penis are not due to action of the muscles, as the latter partake of the general paresis, but are the result of inefficiency of the vaso-motor nerves allowing the blood to flow into the spongy structure of the corpora cavernosa and corpus spongiosum, through the want of resistance in the muscular walls of the vessels."⁵ But this theory of erections arising from passive congestion of the penis is untenable, because it utterly fails to account for the rather numerous examples of priapism in which there are strong or even moderate erections observed, and in which the distension of the organ is produced obviously by an active process. Moreover, vaso-motor paralysis is always attended with a notable rise of temperature in the part of the body where it exists, especially if such paralysis is suddenly effected. How, then, can the occurrence of priapism be explained by the theory of vaso-motor paralysis in such instances as the following, which was reported by Mr. Hutchinson,⁶ in which "there was marked priapism," but attended with a remarkable depression of the body-heat, both general and local, below the normal standard:—

The patient was a man, aged 24, who fractured his fifth cervical vertebra and severely injured his spinal cord by falling from a ladder with a load of bricks on his

¹ Lancet, December 3, 1864.

² New Sydenham Soc. Year-Book, 1864, p. 83.

³ Diseases of the Nervous System, p. 457. New York, 1881.

⁴ Diseases of the Spinal Cord, p. 243. New York, 1882.

⁵ Op. cit., p. 829.

⁶ New Sydenham Soc. Biennial Retrospect, 1873-74, pp. 351, 352.

shoulder. When seen on the following day, his lower extremities were completely paralyzed, and the line of anæsthesia extended as high as an inch above his nipples. The breathing was solely diaphragmatic. There was marked priapism. The temperature was 98° . The pupils were equal and of a small size in a dull light. Next day the pulse was noted at 36 per minute, and small. In the evening, the temperature in the rectum was only 95.8° ; in the distended penis it was only 93° . He died on the sixth day after the accident. The vaso-motor theory of the production of priapism is insufficient to account for such cases, as well as for those instances in which the erections are more or less vigorous, and in which the distension of the penis is obviously effected by the operation of active agencies.

The nervous apparatus, the disordered action of which produces priapism, is doubtless the same as that by which normal erections are effected. The process is a reflex one, the centre for which (that is, the sexual centre) is situated in the lumbar portion of the spinal cord. The sexual centre may be put into action by peripheral impressions conveyed to it from the penis, especially the glans, by the sensory nerves; also, by cerebral impressions (they are usually emotional influences) conveyed to it by the conducting fibres of the cord. "As the result of the stimulation of the sexual centre, an impulse is generated which travels along the nervi erigentes and inhibits the local nervous mechanism in the bloodvessels of the corpora cavernosa; vascular dilatation, engorgement, and erection follow."¹ Thus, it is not difficult to conceive how priapism may be caused in cases where the spinal cord is injured or diseased in the cervical or dorsal regions, etc., and where paraplegia, both sensory and voluntary-motor, is present in consequence thereof, namely, by irritating the "excitor" fibres which pass from the cerebrum to the reflex sexual centre, as pointed out by Dr. Bramwell.² In the same way, cerebral injury or disease may also produce priapism. This view as to the reflex origin of priapism in spinal injuries is supported by a fact noted in the clinical history of a paraplegic case related above, from Bellevue Hospital, viz., that the introduction of a catheter always brought on priapism. Finally, in order to show that the paralysis of the muscular apparatus is not of necessity so complete in cases of seemingly perfect paraplegia that priapism cannot be caused in this way, as asserted by Professor Agnew, it is only necessary to state that, in practice, priapism is very often found associated with retention of urine and feces, and that the presence of the latter condition is due to the fact that the sphincter muscles are not paralyzed.

In regard to the significance of priapism as a symptom, or as a prognostic, in cases of vertebral injury, while it shows that the spinal cord is involved in the lesion, it can be stated with certainty that it is not necessarily a fatal sign, inasmuch as recovery resulted in two cases mentioned above, in which its presence was recorded. One of these cases was reported by Dr. Parker, and the other by Surgeon C. S. Tripler, U. S. Army.

Special treatment is seldom required for priapism. In severe cases, however, pulverized camphor, camphor monobromate, or potassium bromide, may be administered with benefit.

INJURIES OF THE SACRUM AND COCCYX.

FRACTURES OF THE SACRUM.—Simple, uncomplicated fracture of the sacrum sometimes, though very rarely, occurs. The structure, shape, and position of this bone in the skeleton are such as to render it peculiarly free from a liability to sustain solutions of continuity, by itself, in the ordinary accidents

¹ Bramwell, op. cit., p. 129.

² Ibid., pp. 61, 131.

of civil life. It is more often found fissured and even comminuted in the severe crushes of the pelvic bones in general, which are not unfrequently met with. In simple, uncomplicated fracture, the lower half of this bone is the part most liable to be found broken, (1) because it is less strong, and (2) because it is more exposed than the upper half.

Specimens illustrating this lesion are exceedingly uncommon in pathological cabinets. The museum of the Royal College of Surgeons, however, contains one example, according to the statements of both Erichsen and South. In it the sacrum is vertically fractured; the patient died of suppuration six weeks after the accident, and no union of the fragments whatever had taken place.¹ Erichsen has seen but one instance. The injury was caused by a blow from the buffer of a railway carriage, and proved rapidly fatal. Not long ago the following remarkable case was observed in Paris:—

A woman, aged 36, was brought into the St. Lazare Hospital with the history of having fallen about eight feet upon her buttocks; she fainted, and, when she became conscious, was quite unable to sit. A slight transverse depression, corresponding to the middle of the sacrum, was readily felt from behind; the injured part was very tender, and pressure gave fine crepitus. Extensive ecchymosis quickly occurred over the whole sacrum. The line of fracture was readily felt also from the rectum and vagina; the projection forward of the lower half of the sacrum was readily verified, and this part of the bone was easily moved, with crepitus. Reduction was effected without difficulty by the finger pressing backward from the front, and displacement did not recur. A bandage was firmly applied round the pelvis and the patient kept in bed. Defecation gave intense pain, and the woman was unable to lie on her back for a fortnight; but she sat up in bed on the twenty-eighth day, and got up in the ward on the forty-second day. There were no signs of pressure upon, or other injury of, the lower sacral or coccygeal nerves.²

In this case the sacrum was fractured *transversely*; in the specimen contained in the Royal College of Surgeons Museum, mentioned above, it was fractured *vertically*; it is also stated that this bone may be fractured *obliquely*; but, in simple, uncomplicated cases, these fractures are most commonly transverse.

Etiology.—The most frequent causes of the simple, uncomplicated fractures are powerful blows struck directly over the sacrum, as, for example, a blow from the buffer of a railway carriage; heavy falls with direct impingement upon the sacrum, as was observed in the instance just related; and the sudden application of great weight or pressure, such as may occur, for example, in the passage of a cart-wheel over the sacrum. Great force, when indirectly applied, may also cause such fractures; but the indirect fractures of the sacrum are usually associated with similar lesions of the other pelvic bones, as already intimated. Mr. Erichsen has seen one case of simple, uncomplicated fracture of the sacrum which was caused by a blow from the buffer of a railway carriage, and which rapidly proved fatal.

Symptoms.—The pain in the injured part is usually very acute, and aggravated by all muscular movements which disturb the injured part, such as flexion or extension of the body, etc. All straining efforts in defecation, urination, coughing, or sneezing, produce extreme suffering. All pressure applied externally likewise increases the distress; and the patients themselves will generally have noticed that from the moment of receiving the injury they have been, from this cause, unable to sit upright. On examination, angular deformity may be visible posteriorly, as well as a subcutaneous ecchymosis, which quickly spreads over the whole sacral region. On applying the fingers

¹ South's Notes to Chelius's System of Surgery, vol. i. p. 595, Am. ed.

² Lancet, November 20, 1880.

to the injured part, great tenderness is discovered, together with crepitus and one or more lines of depression corresponding to the fracture and displacement. On introducing a finger into the rectum, and pressing against the coccyx, both crepitus and abnormal mobility may be detected. With a finger of one hand in the rectum and the fingers of the other hand applied externally, the kind and degree of the displacement can for the most part be readily determined. The displacement usually consists in a forward projection of the inferior fragments, as was observed in the example of sacral fracture above related, and is due to the operation of two causes, (1) the blow itself, and (2) the contractions of the *gluteus maximus*, *coccygeus*, and *sphincter ani* muscles. Lateral distortion is not likely to occur, because the lesser and the greater sacro-sciatic ligaments would counteract such a change in the position of the fragments. Moreover, paralysis of the bladder and rectum may likewise be present, inasmuch as both organs receive nerves from the sacral plexus.

Prognosis.—Of the three examples mentioned above, two ended in death, and but one in recovery. The successful case, however, shows that when simple fracture of the sacrum is not complicated with other lesions, especially with injuries of the pelvic viscera, the fragments on being placed in apposition readily unite, and recovery speedily ensues; for in that case the union on the twenty-eighth day was already so firm that the patient sat up in bed, resting of course the whole weight of her trunk upon the injured bone in so doing. When, therefore, fractures of the sacrum do not end in recovery, the fatal result is generally due, not to the fractures themselves, but to lesions of the adjacent pelvic viscera with which they are associated. Unhappily, however, any application of force that may suffice to disrupt the sacrum, is very liable to do so much harm to the neighboring pelvic organs, at the same time, as to make a fatal result inevitable. Thus, it appears that the prognosis in sacral fractures depends rather upon their complications than upon the fractures themselves, and that it is generally unfavorable.

When the lesion consists in the breaking off of a layer of bone attached to the cartilage at one or both of the sacro-iliac synchondroses, that is, in modified diastasis, the issue is not of necessity mortal. Dr. Banks¹ has recorded an example of this lesion in which there was displacement upward to the extent of one inch, and still the patient recovered. Moreover, a cure is sometimes obtained in still more unpromising instances, where the fracture is compound, and at the same time complicated with injury of the bladder; for Dr. Burlingham² has reported a very remarkable case of compound fracture of the sacrum in which the urine flowed for some time through the wound, and in which, notwithstanding this condition of affairs, the patient entirely recovered.

Treatment.—Fractures of the sacrum should always be reduced when practicable, and the reduction can generally be effected without much difficulty when the fracture is situated in the lower half of the bone (which is the part most liable to be broken), especially if it happen to be transverse. Reduction is to be effected even when the displacement is but slight, because, from the close proximity of the rectum, any displacement whatever of the fragments that might be allowed to remain, would correspondingly tend to irritate that viscus, and to excite suppurative inflammation in the loose connective tissue between it and the injured bone. It should be remembered in this connection that death resulted from such a suppuration, six weeks after the accident, in the case the specimen from which is preserved in the Royal College of Surgeons (mentioned above), and that, as might well be expected under the circum-

¹ *Atlanta Medical and Surgical Journal*, May, 1866.

² *American Journal of the Medical Sciences*, April, 1868.

stances, no union of the fragments whatever had taken place. No doubt too the remarkable success which attended the treatment of the illustrative example related above, was mainly due to the fact that the displaced bone was put back again into its normal position without delay, and that an exact apposition of the fragments was uninterruptedly maintained. Oftentimes, reduction can easily be accomplished by pressing upon the displaced bone with a finger in the rectum.

The second indication in the treatment of sacral fractures is to keep the fragments in apposition. This indication was readily fulfilled in the illustrative example presented above, by firmly applying a bandage around the pelvis, and by keeping the patient in bed. But the main difficulty in the treatment of these cases, where the fracture is the sole injury, is the intense degree of pain with which the act of defecation is accompanied, and the local disturbance which it produces. Some surgeons have, by administering opium, kept the bowels in a state of confinement; and then emptied the rectum every week or ten days by means of an enema. It is, however, still better to diet the patient very carefully with a view to restrain the production of feces to the smallest possible quantity, which may then be easily and almost painlessly removed every three or four days by means of an enema. Whenever pain is present in these cases, it must be subdued by administering opium or morphia in doses that are sufficiently large, and at intervals that are sufficiently brief. Should intra-pelvic inflammation arise, it must be combated by leeches and hot fomentations, as well as by opiates. Should retention of urine be present, catheterization must be employed every eight hours. Should the bladder be wounded in a male patient, but especially should it be ruptured, it may be advisable to open it at once by perineal section in order to allow the urine to escape as fast as secreted, and thus avoid all chance of urinary infiltration. Cases belonging to this category may be saved by the timely performance of this operation, which is not dangerous *per se*, and which, if I remember aright, has already proved successful in one or more examples of this sort, simply because it prevented the pelvic fractures from becoming complicated with urinary infiltration.

But should the broken bone manifest a disposition to slip out of place again after its reduction has been effected, notwithstanding the firm application of a bandage around the pelvis, a mechanical apparatus must be employed to overcome this disposition. For this purpose, M. Indes used simply a piece of wood, cylindrical in shape, five inches in length by three inches in circumference, which was inserted into the rectum, and there retained in position by graduated compresses together with a T-bandage. On every third day this plug or splint was temporarily withdrawn, and the bowel was washed out with an enema. The patient recovered. For the same purpose, M. Bermond used a silver canula, with a bag attached, which when stuffed formed an inner and an outer tampon. The end of the tube was kept closed with a cork, in order to prevent the escape of feces. It was removed only twice during the course of treatment, namely, on the seventh and nineteenth days respectively. This patient also recovered.

The patient should be rigidly confined to bed until the fragments have united. The posture therein should be that which is attended with the smallest amount of discomfort to the patient, and with the smallest liability to the recurrence of displacement.

GUNSHOT FRACTURES OF THE SACRUM.—Hennen mentions three cases in each of which a musket-ball passed through the sacrum, about three inches above the tip of the coccyx, and penetrated obliquely upward. In two of them the rectum was also wounded. In the third, the bladder was perforated as well as

the rectum, and "urine passed after the first few hours from the posterior wound." This patient expired on the third day, "laboring under the symptoms of the most violent peritonitis." In each of the other cases the missile lodged, and was passed by stool about two months after the casualty. One of these unfortunate men "survived for two years, when, a discharge of feces coming on through the orifice in the bone, he died, exhausted by a complication of sufferings; but no paralytic affection ever appeared." The remaining case was seen by Dr. Thomson in the military hospital at Berlin, under the care of Dr. Reich, but the result is not stated.¹ From this it would appear that shot fractures of the sacrum are highly dangerous to life. Paré, however, asserted that he had many times seen the sacrum fractured by bullets when the subjects recovered. During the late civil war one hundred and forty-five cases were reported. In three of them the result has not been determined. Of the remaining one hundred and forty-two instances, sixty-two, or 43.7 per cent., were fatal.² Thus it appears, (1) that gunshot fractures of the sacrum not unfrequently occur, and (2) that more than one-half of the cases recover.

The following very instructive example eventuated in recovery:—

Lieutenant W. A. C. Ryan, Co. G, 132d New York Volunteers, aged 21, was wounded at Bachelor's Creek, N. C., February 1, 1864, by a conoidal ball, which fractured the last lumbar vertebra, and lodged in the sacrum. He was at once taken to a general hospital where simple dressings were applied to the wound. On June 12, it was noted that the wound discharged very freely; that the patient although feeble was in a very good condition; that an ulcer had formed across the sacrum, about three inches in length by one and a half inches in width, with a sinus leading to the ball; and that the missile was extracted, with some difficulty, from the bone in which it was firmly imbedded, on that day. The wound healed rapidly after the operation. The treatment consisted of tonics, with a generous diet. On October 9, the patient was discharged. There is no record of him at the pension-office.³ His recovery was, therefore, in all probability complete.

Recovery resulted in the next example also:—

Lieutenant S. W. Russell, Co. B, 49th New York, and A. D. C. Sixth Corps, aged 26, was wounded at Rappahannock Station, November 7, 1863, by a conoidal ball which "entered the left hip, passed across the upper portion of the sacrum, and emerged from the right hip. The surface of the sacrum was fractured." On the 9th he was admitted into Armory Square Hospital, and on February 3, 1864, he was transferred to Seminary Hospital, Georgetown. He returned to duty on May 16 following, where he appears to have remained until June 27, 1865, when he was discharged from the service and pensioned. The pension-examiner noted at the time that the wound was still unhealed. On June 4, 1873, he was still on the pension list.⁴

Among the cases of recovery from shot fractures of the sacrum, reported during the late civil war, were four in which the bladder was penetrated. In nine instances the rectum was wounded, and eight of these cases resulted favorably. In addition to the complications attending shot injuries of the os innominatum, paralysis and other disorders referable to lesions of the nerves were common after shot fractures of the sacrum.⁵

In the cases of shot fracture of the sacrum which were observed during our late civil war, it was common for one or both of the posterior spinous processes of the ilium to be found fractured at the same time, as is shown in

¹ Hennen, op. cit., p. 351.

² Medical and Surgical History of the War of the Rebellion, Second Surgical Volume, p. 246.

³ Ibid., First Surgical Volume, p. 461.

⁴ Ibid., Second Surgical Volume, p. 246.

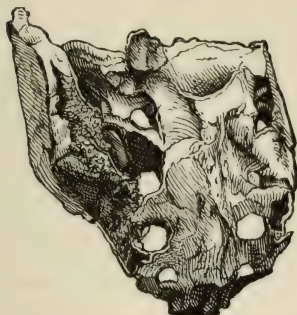
⁵ Ibid.

the preparation represented by Fig. 884, and as probably happened in the case of Lieutenant Russell, which has just been related.¹

Shot fractures of the sacrum were not unfrequently found by our military surgeons to become complicated with *pyæmia*, as was observed in the following instance:—

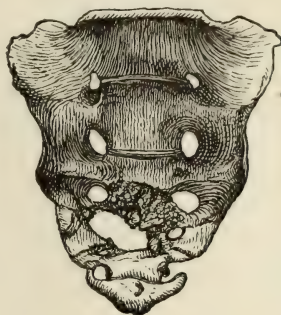
Private George F., aged 23, was wounded at Cold Harbor, June 3, 1864. He was treated in the field hospitals until the 12th, when he was transferred to Washington, and admitted to Douglas Hospital. At this time he was suffering from partial paraplegia. He died from well-marked pyæmia on the 21st, eighteen days after the casualty

Fig. 884.



Shot fracture of the sacrum and ilium.
(Spec. 1353, A. M. M.)

Fig. 885.



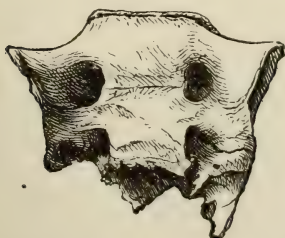
Shot perforation of the sacrum.
(Spec. 3568, A. M. M.)

occurred. *Autopsy*.—The ball was found in two pieces in the sacro-ischiatic notch, having perforated the sacrum to the right of the median line, as shown in the accompanying wood-cut (Fig. 885), which represents the osteological specimen that was obtained from the case, and is now preserved in the Army Medical Museum. Both lungs contained extensive pyæmic patches; the liver and spleen were softened, and the latter enlarged. There had been icterus before death.²

Pyæmia was reported as the cause of death in eight of the sixty-two fatal cases belonging to this category, or 12.9 per cent.³

The specimen represented by Fig. 886 was obtained from the corpse of a soldier, aged 41, who was wounded at Petersburg, July 30, 1864, by a conoidal ball. He was

Fig. 886.



Upper two-thirds of the sacrum obliquely fractured
by a conoidal musket-ball. (Spec. 3586, A. M. M.)

Fig. 887.



Right half of the sacrum grooved by a conoidal
musket-ball. (Spec. 230, A. M. M.)

admitted to Douglas Hospital on August 3, and died after symptoms characteristic of pyæmia on the 10th, twelve days after the casualty occurred. For three days after

¹ Ibid.² Ibid., p. 247.³ Ibid.

admission catheterization was required, but after that his water passed freely. There was no other sign of paraplegia.¹

The specimen represented by Fig. 887 was obtained from the cadaver of a soldier, aged 19, who was wounded at West Point, Va., May 7, 1862, and who died in Judiciary Square Hospital, at Washington, on the 23d, with symptoms of pyæmia, sixteen days after the wound had been inflicted. The injury was reported as a "gunshot wound of the lumbar region near the nates, and also through the lower part of the right chest." "*Post-mortem* section of the injured parts showed a deep wound of the sacrum ploughing the bone," as is well shown in the accompanying wood-cut.²

In the following instance the sacrum was transversely grooved or perforated by a small-arm missile:—

Corporal Amos E. C., aged 18, was wounded at Chancellorsville, May 3, 1863, by a conoidal musket-ball, which entered the left buttock behind and above the great trochanter, and emerged through the right side of the sacrum. He remained in the hands of the enemy for nine days, during which time his wound was entirely neglected. On June 14 he was sent to Washington, and was admitted to Douglas Hospital in a very nervous, weak, and anæmic condition. There were bed-sores over the projections of the hips, back, and sacrum, so that it was impossible to lay him in a comfortable position. He died on July 9, apparently in consequence of these bed-sores. *Autopsy.*—Pleuritic adhesions were found, but no signs of peritoneal inflammation. The sacrum, as shown in the accompanying wood-cut (Fig. 888), was perforated from side to side, with loss of substance at the junction of the fourth and fifth pieces of the bone. The fragments were carious, and there was a slight osseous deposit on the anterior surface.³

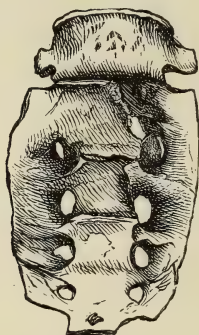
The specimen of shot fracture of the sacrum which is represented by Figs.

Fig. 888.



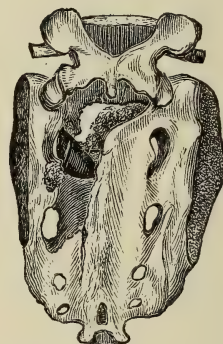
Showing the sacrum grooved transversely by a conoidal musket-ball. (Spec. 1642, A. M. M.)

Fig. 889.



The sacrum and last lumbar vertebra. A ball is impacted in the left upper sacral foramen. (Spec. 2902, A. M. M.)

Fig. 890.



Posterior view of the same specimen.

889 and 890, was obtained at the autopsy of a soldier, aged 23, with the following history:—

He was wounded at Spottsylvania, May 10, 1864, and taken to a field hospital of the Fifth Corps. On the 14th he was transferred to Carver Hospital, at Washington. "The missile entered about two inches to the left of the sacrum, passed a little downward and to the right, fractured the sacrum, and remained in the wound. When admitted, the patient was not much emaciated; there was great pain, with tumefaction of the abdomen; the bowels were constipated, and there was complete retention of urine. The bladder was greatly distended with urine; the pulse about 140; the tongue thickly coated with dark-colored fur; sordes on the teeth. There was also partial

¹ Ibid.

² Ibid.

³ Ibid., p. 248.

paraplegia. The catheter was introduced and the bladder relieved. The missile was searched for unsuccessfully. Opiates were then administered. He continued to sink and was perfectly unconscious. The pulse was 160." He died May 15, that is, five days after the wound was inflicted.¹

The cause of death is not stated, but, judging from the symptoms as detailed above, it was traumatic peritonitis. At any rate, peritoneal inflammation must be a frequent consequence of shot wounds such as this. This case is doubly interesting because of the paralysis of the bladder and lower extremities which resulted from the injuries sustained by the sacral nerves.

The following example is very instructive, as well as interesting, because of the peculiar form of paralysis, and the hæmaturia, which resulted from the primary lesion:—

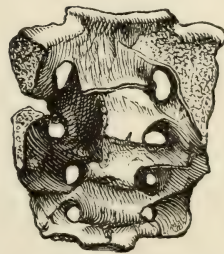
Private Peter K., aged 32, having been wounded at the South Side Railroad, on April 1, 1865, was sent to Washington, and admitted to Douglas Hospital on the 6th. A conoidal musket-ball had entered the left buttock nearly on a level with the second vertebra of the sacrum, about four inches from the spinous process thereof, had passed through or across the sacral portion of the spinal canal, and had lodged in the right wing of the sacrum, near its junction with the ilium. There was complete paralysis of the bladder and rectum, with constant hæmaturia; but no paralysis of the lower extremities. On the 8th, the patient failed rapidly, and became partially insensible. He died on the 9th, from exhaustion, eight days after the casualty occurred.² The specimen is represented by the accompanying wood-cut (Fig. 891). The vesico-rectal paralysis observed in this case is easily accounted for; but what caused the hæmaturia? Did it arise from a neuropathic congestion of the kidneys, such as we have seen occurs not unfrequently in cases of spinal injury?

Fig. 891.



Showing the sacrum with a ball impacted at the left second intersacral notch. (Spec. 2542, A. M. M.)

Fig. 892.



Showing a shot fracture of the sacrum. (Spec. 3001, A. M. M.)

In the next case there was a complete transverse fracture observed:—

Private P. McC., aged 20, was wounded at Carrion Crow Bayou, La., November 3, 1863. He was treated on the field until the 8th, when he was admitted to University Hospital, New Orleans, where he died on the 22d, nineteen days after the infliction of the wound. The case is described as a gunshot fracture of the sacrum; "the missile, passing obliquely from the left, entered near the median line at the junction of the second and third sacral vertebrae, and escaped into the pelvis through the right portion of the second vertebra. The sacrum was completely fractured transversely at that point." The specimen is represented by the accompanying wood-cut (Fig. 892).³

In the following example, traumatic spinal meningitis with tetanic spasms occurred:—

Private W. M. R., aged 22, was wounded at Winchester, July 20, 1864, by a conoidal musket-ball, which penetrated the sacral region five inches above the anus, and one

¹ Ibid.² Ibid.³ Ibid., p. 249.

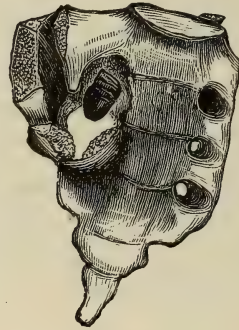
inch to the left of the median line, passed obliquely upward and forward, and lodged. There was retention of urine, but no paralysis of sensation or voluntary motion. On the 25th he was very restless, and suffered great agony from the wound. But little change was noted until August 6, when slight tetanic spasms, with delirium and unconsciousness, occurred. They continued with increasing severity. On the 8th, opisthotonic spasms recurred at frequent intervals, the pupils were largely dilated and fixed, and he died on that day. *Autopsy*.—The missile was found about three inches from the point of entrance, embedded in muscular tissue. The spinal column was in a suppurating condition. The osteological specimen, represented by Fig. 893, was sent to the Army Medical Museum. It consists of a wedge-shaped portion of the sacrum, showing a fracture into the spinal canal at the second sacral vertebra, with the first and second spinous processes wanting from being broken off.¹

Fig. 893.



Showing a shot penetration of the sacral canal. (Spec. 4258, A. M. M.)

Fig. 894.



Showing the sacrum and a part of the right ilium, with the bullet which perforated the former. (Spec. 1245, A. M. M.)

This case, in which the upper part of the sacral canal was opened by a gunshot missile, is a very important one, because traumatic spinal meningitis ensued. The symptoms appeared on the fifth day, and were extreme restlessness, and "great agony" from pain in the wound, followed by tetanic spasms, which steadily increased in severity until opisthotonos followed, with delirium, unconsciousness, and death. The *autopsy* revealed a suppurating condition of the spinal canal. Another instance of shot-fracture of the sacrum in which death resulted from spinal meningitis and myelitis, is likewise reported in the same volume, on page 248. (Case 726.) "The lower part of the spinal cord was softened, and of a dark appearance." In this case, too, the missile after striking the sacrum lodged.

The very interesting specimen which is represented by Fig. 894, was obtained at the autopsy of a soldier, aged 26, who was wounded by a conoidal musket-ball at Chancellorsville, May 3, 1863, and died at Douglas Hospital nineteen days afterward, apparently from septicæmia. The case is also remarkable for the absence of peritonitis and paralysis.²

In the next example the missile lodged in the spinal canal, and, notwithstanding that the cauda equina was compressed by it (through the meninges), the sensibility and motility of the lower extremities were not affected:—

Private Michael H. was wounded June 27, 1862, at Gaines's Mills, Virginia, and died of exhaustion on December 27. The wound closed, and there were no symptoms

¹ Ibid.² Ibid.

for about three months. On October 20, after dissipation, he complained of pain in the left knee, at times very intense, depriving him of rest. The wound reopened and discharged freely; a slough formed over the lower part of the sacrum, three or four inches in diameter, and so deep as to lay the bone bare. A lumbar and psoas abscess developed itself; the pain in the left knee increased greatly, and the left leg became swollen and tender to pressure. The abscess in the loin was opened by a valvular incision, and three pints of pus were discharged, with great relief to the pain in the leg, etc. Both legs became swollen about December 20, and he died as stated above, exactly six months after the occurrence of the casualty. At no time was there any paralysis of motion or sensation in the lower extremities or elsewhere. *Necroscopy.*—An immense abscess extending from the left kidney to Poupart's ligament was found. In the pelvis, in contact with the sacrum, there was another abscess, while the tissues of the pelvis, at its back part, were buried in effusions of plastic matter. The ball was found lodged in the spinal canal, opposite the fifth lumbar vertebra, as shown in the accompanying wood-cut (Fig. 895). It had entered on the right side of the spinal ridge of the sacrum, about its middle, passed diagonally upward, and spent its force on the left wall of the canal of the first sacral and fifth lumbar vertebrae. The left lamina of the first sacral bone was carried away. The missile had passed up the spinal canal outside of the theca vertebralis. The bodies of the fourth and fifth lumbar vertebrae were carious, and the intervertebral cartilage between them was entirely destroyed. The first and second sacral vertebrae were necrosed and discolored, as was also the fifth throughout its thickness. The first and second left sacral nerves seemed most involved by the diseased bones, but the left lumbar plexus was entangled in the diseased mass which occupied the basin of the pelvis.¹



Showing the sacrum and last three lumbar vertebrae, with a ball lodged in the spinal canal opposite the fifth lumbar vertebra. (Sp. 1198, A. M. M.)

The complete closure of the wound, and the development of caries and necrosis in the bony structures which had sustained the shock or impact of the missile, after the lapse of three months, are worthy of special remark in this place, as well as the fact that no paralysis whatever occurred.

From the foregoing, it appears that the chief risks which were encountered in treating shot fractures of the sacrum during our civil war, were the superinfection of (1) *pyæmia* or *septicæmia*, (2) *traumatic spinal meningitis and myelitis*, (3) *peritonitis*, and (4) *caries and necrosis* of the injured bones, with the formation of corresponding abscesses in the pelvis, as well as in the sacral and lumbar regions.

Treatment.—When the missile lodges, in cases of shot-fracture of the sacrum, it should, if possible, always be extracted. One case has already been related in which this was done with an excellent result. I shall now present two additional cases in which important operations were performed to the same end, with good effect.

Surgeon J. J. Chisolm relates² the case of a young Confederate soldier belonging to the 26th Alabama Regiment, who was shot in the back. The missile passed through the sacrum an inch from its spinous processes, and one inch below the level of the crest of the ilium, and lodged. Eight months after the reception of the wound, he applied to Dr. C. for relief, inasmuch as he had a constant discharge of pus from both the wound in the back and a fistulous passage in the left groin. Upon examination with a probe, which penetrated four inches, traversing the sacrum, the foreign body was detected, the bulb of the probe entering the cup of the minié ball. By enlarging the hole through the sacrum with a gouge, room was obtained to draw the ball from the pelvic cavity. The patient recovered.

¹ Ibid., First Surgical Vol., p. 449.

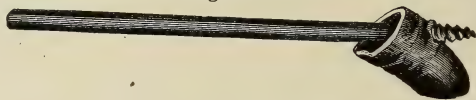
² Manual of Military Surgery, 1863, p. 356.

In the following instance a trephine was applied for the same purpose :—

Private H. F. Norcross, aged 20, was wounded in the right gluteal region, at Drury's Bluff, May 16, 1864. The track of the ball was traced to the second segment of the sacrum, and the missile was apparently embedded deeply in the bone. On March 9, 1865, Dr. E. B. Lyon reported that "there was an open sinus on the right buttock communicating with the lodgment of the ball in the sacrum, and discharging freely. The constitutional condition was comparatively good. Ether was administered, and an oblique incision, six inches in length, was made, exposing the orifice in the sacrum. A trephine was then used to enlarge the orifice in the bone. The ball was divided and removed in seventeen parts. Simple dressings were applied." The wound healed kindly. On July 10, he was discharged from the service and pensioned. In September, 1873, he was still on the pension list, his disability being rated at one-half.¹

For the removal of injured or diseased bone, or for the extraction of impacted projectiles, there were in all twenty-five operations performed during our civil war, in cases of shot fracture of the sacrum. In one instance, where the missile was discovered "firmly embedded in the body of the sacrum, beyond the reach of forceps, it was extracted by means of a common ramrod, a piece of which remains in the bullet as when taken out." The specimen is represented by the accompanying wood-cut (Fig. 896). It is preserved in the Army Medical Museum.²

Fig. 896.



Showing a conoidal ball which was extracted from the sacrum with a ramrod. (Spec. 1123, A. M. M.)

The most important points in the treatment of shot fractures of the sacrum are the following: (1) The removal of all foreign bodies, under which term all loose fragments of bone, all pieces of clothing and accoutrements, etc., as well as the missiles themselves, are included; (2) the application of antiseptic dressings to the wounds; and (3), the early and thorough use of Chassaignac's drainage-tubes. By antisepsis and prompt drainage of the wounds the risk of pyæmia and septicæmia will be greatly lessened. Any tendency to peritonitis or to inflammation of the spinal membranes, which may be evinced, must be combated by administering opium or morphia in full doses at short intervals. Should spinal meningitis supervene, it will require the exhibition of ergot and potassium iodide in full doses, as already pointed out.

SIMPLE FRACTURES OF THE COCCYX.—In the years 1859 and 1860, I made the surgical examination of an old pensioner from the war with Great Britain, of 1812–15, whose disability had resulted from simple fracture of the os coccygis caused by the kick of a horse, and found that bone bent strongly forward and to one side, and rigid in that position. He stated that his injury was still the source of almost constant discomfort, that it always interfered with the act of defecation, and sometimes made it painful, and that it still made it impossible, most of the time, for him to sit while working at his trade of saddler and harness-maker.

Professor Ashhurst³ mentions a case taken from the records of the Pennsylvania Hospital, in which there was fracture of the coccyx, as well as comminuted fracture of

¹ Medical and Surgical History of the War of the Rebellion, Second Surgical Vol., p. 251.

² Ibid.

³ Op. cit., pp. 116, 117.

the lumbar vertebræ and fractures of both legs, caused by falling from the sixth story. Death ensued in one day. The *autopsy* showed that the cause of death was internal (post-peritoneal) hemorrhage and exhaustion.

Professor Agnew¹ states that he has known a case in which this accident resulted from a rider's coming down upon the back of the saddle in an attempt to mount a restive horse.

Mr. South² says he has known two cases where this accident was not recovered from for nearly two years: "The one followed sitting down suddenly on the edge of a snuff-box, which was jammed in between the side of the coccyx and the spine of the haunch bone; and the other by the patient having been thrown from a horse upon a heap of stones. In these cases the pain was not so great as usually said to be in walking, because the patients learned to walk without disturbing the bone; but the pain was agonizing when they incautiously sat down on a soft seat. Leeching afforded only temporary relief; and the cure was at last effected, after months, by protecting the coccyx from all possibility of pressure, by constantly wearing a pair of very thick oblong pads on the ischial tuberosities, so that in sitting the point of the coccyx was in a deep pit."

Simple fractures of the coccyx are said sometimes to occur during parturition, in consequence of the pressure exerted by the fœtal head while passing through the inferior strait of the pelvis; but it is probable that such cases often consist of luxation, or rupture of the coccygeal ligaments, instead of fracture.

This accident is of infrequent occurrence. It may be caused by kicks, by blows, by falls, and by injuries sustained during parturition. Though seemingly a very trivial accident, it is often exceedingly painful and annoying for many months or years, or even for a lifetime.

The displacement in fracture of the coccyx is forward, and it is produced by the same agencies as those which cause the deformity in simple fracture of the sacrum, namely, the contractions of the muscles which are inserted into the coccyx, as well as the general direction of the fracturing force.

Treatment.—Although the injury at first sight may appear inconsiderable, the victims of this accident, for reasons presented above, should always be confined to bed, in that posture which is least painful, and which causes least disturbance of the injured bone. Any forward displacement should be corrected by inserting a finger, well oiled, into the rectum, and pressing the bone back into its normal position. If the deformity returns, it may become advisable to employ such tampons as have been described while discussing fractures of the sacrum. Should much inflammation supervene in the injured part, the application of leeches, followed by a lotion composed of lead-water and laudanum, will prove useful in subduing the inflammatory action, and in diminishing the liability to the occurrence of neuralgia, necrosis, abscess, and fistula. Should, however, the ligamentous tissue surrounding the bone continue inflamed and painful, notwithstanding the treatment, and especially should the apex of the injured bone be incessantly dragged forward by spasmodic action of the sphincter ani and other muscles which are inserted into the os coccygis, it may be proper to forcibly stretch the sphincter, under ether, as in cases of anal fissure, so that the fibres of that muscle may be paralyzed for a time, and that defecation may take place without spasm and without restraint. After such patients leave their beds, it will often be useful for them to protect the coccyx from injury by constantly wearing a pair of thick oblong pads on the tuberosities of the ischium, as recommended by Mr. South.

¹ Op. cit., vol. i. p. 923.

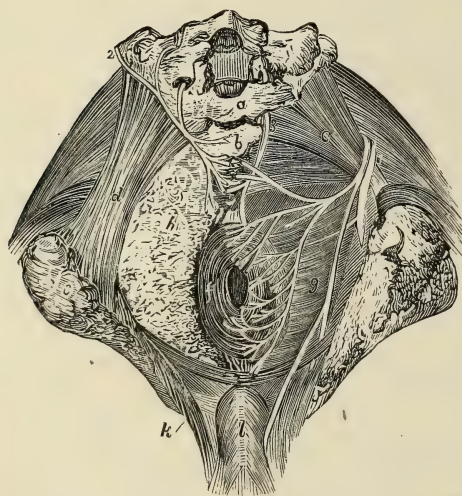
² Notes to Chelius's Surgery, vol. i. pp. 595, 596, Am. ed.

GUNSHOT FRACTURES OF THE COCCYX.—In shot wounds of this sort, the lesion of the bone is commonly but a small part of the whole injury. There were seventeen cases of shot fracture of the os coccygis reported during our civil war, of which six, or 35.3 per cent., were fatal. In twelve cases, with five deaths, the coccyx was the only bone involved; in four cases, terminating favorably, there were attendant fractures of the sacrum; two, one of which was fatal, were associated with fractures of the pubis. In one case a ball is said to have been found imbedded in the coccyx. In all the fatal cases, death appears to have resulted from the injuries sustained by other parts. Still, visceral lesions were less frequently present as complications of shot fractures of this bone, than would be anticipated from its anatomical relations.¹

In regard to *treatment*, the irregularity and variety of the complications preclude the establishment of any special rules. The early removal of sequestra and foreign bodies is, of course, indispensable. Free though cautiously directed incisions may be requisite to prevent the burrowing of pus. Extreme attention to cleanliness, and to the prevention of fecal accumulation in the rectum, as well as watchfulness over the state of the bladder, are precautions that must not be overlooked.² The wounds must be dressed antiseptically, and drainage tubes must likewise be inserted, in many cases, in order to insure that no confinement of inflammatory products shall take place.

COCCYGODYNIA.—The damage sustained by the sacro-coccygeal and other spinal nerves, in connection with injuries of the os coccygis, often gives rise

Fig. 897.



a, Sacrum. b, Coccyx. c, Tuberosity of ischium. d, Greater sacro-sciatic ligament. e, Lesser sacro-sciatic ligament, with pudic nerve on its posterior aspect. f, Sphincter ani. g, Levator ani. h, Fatty and connective tissue.

- 1, Pudic nerve and its branches.
- 2, Posterior branches of the 2d, 3d, and 4th sacral nerves proceeding to posterior aspect of the coccyx.
- 3, Sacro-coccygeal nerve distributed over apex of the coccyx and adjacent soft parts. (Hilton.)

to an exceedingly painful state of the soft parts overlying the bone, which has been denominated *coccygodynia*. The accompanying wood-cut (Fig. 897), which indicates the numerous nerves of sensation that are distributed over the coccyx, and to the lower part of the rectum as well as to the margin of the anal aperture, shows at a glance the anatomical and physiological explanation of this distressing affection.

For the relief of coccygodynia, it was advised by the late Sir James Y. Simpson, to introduce a narrow bistoury between the soft parts and the bone, and completely sever the connections between them. Should this simple procedure fail, and the symptoms continue severe, it may be necessary to excise the bone itself. When caries or necrosis is present, excision of the bone is always necessary.

In regard to operative procedures, Van Onsenoort and Ollier have extirpated the coccyx for caries, and Nott, Simpson, and many others have performed the same operation with impunity for neuralgia (coccygodynia).

¹ Medical and Surgical History of the War of the Rebellion, Second Surgical Vol., pp. 252, 253.

² Ibid., 253, 254.

Dr. James E. Garretson¹ has proposed and successfully performed the operation of removing the coccyx without disturbing the perineal anatomy, by the employment of a dental engine. This operation was done at Penn Manor, on the person of a lady who had suffered from coccygodynia for thirteen years. Exposure of the coccyx revealed it as fractured and standing at right angles with the sacrum. Dr. Garretson's proposition was to remove the bone by simple enucleation; in other words, to remove the osseous tissue from its envelope of periosteum without disturbing the under layer thereof which is the surface of attachment for the soft parts constituting the posterior perineum, and, of course, without disturbing the relations of the structures which constitute the perineum itself. The operation was performed in the following manner:—

The patient being etherized and placed partially upon her abdomen, an arm being under the body at the region of the diaphragm, to secure freedom in respiration, an incision was made through the skin and superficial fascia, the length of the coccyx. These tissues being carried to either side by means of retractors, a second incision was made through the periosteum, and by means of a chisel-shaped knife this structure was raised and everted. In this last is the peculiarity of the operation: it is as though one might cut down the centre of the upper surface of an envelope, exposing, in the turning aside of the paper, a letter lying on the lower face of the envelope, the turned-aside upper part being of continuity with the bottom of the paper. A succeeding step employs the engine. A circular burr, the face side alone of which is cut, is placed in the grasp of the handpiece, and while in revolution to the extent of ten thousand times to the minute, is applied, with delicacy of manipulative touch, to the surface of the bone. In the case here recorded, five minutes sufficed for the disappearance of the coccyx in the shape of bone dust, the under face of the periosteum remaining as undisturbed as though it had never been in relation with the coccyx. The wound, a superficial one, was put up to heal by first intention.

I believe this operation to be a very good one, and therefore I have taken the space requisite to describe it.

REMOTE EFFECTS OF SPINAL INJURIES, RAILWAY SPINE, ETC.

When *fractures* or *dislocations* of the spinal column eventuate in recovery, there occurs, as a rule, ankylosis, with immobility or inflexibility of the injured part of the column. Any vertebral displacement which may have been allowed to remain will constitute a deformity. Among the remote effects of spinal fractures and dislocations, *ankylosis*, *stiffness* or *inflexibility*, and *deformity* must therefore be enumerated. In cases where the cervical portion of the column has been thus injured, the inflexibility and deformity may cause much inconvenience in many ways, and may also interfere, seriously and persistently, with the act of swallowing. These points are well illustrated by the following case:—

George Reid, aged 29, a tailor, was admitted into Bellevue Hospital (Dr. Stephen Smith's Ward) on August 5, 1858, for cephalalgia, the result of an injury. He was short in stature, but well made and well nourished, and free from constitutional taint and tendency.

Upon external examination, the fifth cervical vertebra, its spinous process, etc., were found displaced forward; upon examination through the mouth, the body of this vertebra was felt projecting forward, and forming a large prominence in the pharynx. He was unable to swallow solid food to any considerable extent. This dysphagia and the necessarily awkward position in which he was forced to carry his head were the only

¹Annals of Anatomy and Surgery, March, 1882.

local difficulties now present, which resulted from the vertebral displacement. The vertebræ themselves were firmly fixed in their new position. His general health was good.

History.—In September, 1856, the patient fell backward down fifteen stairs, and struck upon the back of his head and neck. He was rendered insensible, and remained so for three hours. He has never been able to recollect anything in regard to his fall, his memory otherwise being unimpaired. There was no wound nor contusion, nor any other external evidence of injury upon his neck. With returning consciousness he did not become aware of his injury until he attempted to rise from the bed. He then felt an acute, spasmodic pain in the back of his neck, which subsided immediately on lying down again. This pain in the back of his neck, on motion, continued three months. Three weeks subsequent to the accident, he began to have severe pain in the back of his head—usually nocturnal—and at that time was admitted to this hospital in the service of Dr. Charles D. Smith. Excepting the pains just mentioned, and dysphagia, he has not had any subjective symptoms of spinal injury. There have been no anæsthesia, no paralysis, no difficulty in breathing, micturating, or defecating, and no increase of temperature.

His general health being good, he was discharged as affording no particular indication for treatment.¹

The “awkward position” mentioned above in which the patient was compelled to carry his head is not described in words, but it was doubtless the following: Inasmuch as the original lesion of the spinal column consisted in a forward dislocation of the body of the fifth cervical vertebra upon that of the sixth, there occurred in consequence of the action of the muscles directly or indirectly involved, together with the superimposed weight of the head, a forward bend in the spinal column at the place of injury, which widely separated the spinous process of the fifth cervical vertebra from that of the sixth, and likewise caused the neck and head to present a “thrust-forward” appearance, as well as to acquire a “thrust-forward” position. It certainly must have been very awkward for the patient to carry his head always in that manner. And had the deformity been removed at the outset by reducing the dislocation, it would have been much better for the patient, because by so doing his difficulty in swallowing would have been obviated, and his head would have been placed in a much more comfortable position.

The pain in the back part of this patient’s neck and head which followed the accident, and still persisted two years afterward in a troublesome or distressful degree, was probably due to meningeal irritation, or a low grade of meningeal inflammation, which itself resulted from the fact that the dislocation was not reduced, and that the theca vertebralis was consequently stretched and irritated by the injured vertebræ in their abnormal positions. Thus it appears that pains arising from *meningeal irritation* and *inflammation* (both spinal and cerebral) must also be enumerated among the remote effects of vertebral fractures and dislocations. Moreover, much difficulty will often be experienced in controlling this meningeal disorder, unless perchance the causal indication in its treatment has previously been fulfilled, by “setting” the fractured or dislocated vertebræ, and thus removing the displacement upon which its existence mainly depends. The remedial measures to be employed in such cases are dry cupping and setons, together with the administration of potassium iodide in full doses, alternated with corrosive sublimate, for a long period.

Among the remote effects of *sprains*, *wrenches*, and *twists* of the spinal column, are chronic *inflammation of the vertebral joints* that are implicated, which is often suppurative in character, *destruction of the articular cartilages* and the *intervertebral substances* that are involved, and *caries* or *necrosis* of

¹ New York Journal of Medicine, March, 1859, p. 246.

the adjoining vertebral bodies. In such cases, the destructive process begins more frequently at the junction of the vertebræ with the intervertebral substances than in the intervertebral substances or vertebræ themselves, because, as Mr. Hilton has pointed out, we know that in accidents, at least as far as we have been able to discover, "the most frequent lesion in injury to the spine is a partial severance of the vertebra from the intervertebral substance."¹

A number of illustrative examples have already been presented,² and inasmuch as this topic has already been pretty thoroughly discussed, no apparent need exists for presenting any additional instances of the same sort. I will, however, take space to present a very instructive case, in which there simultaneously occurred lumbo-sacral abscess and suppurative spinal meningitis, in consequence of a blow on the spinal column:—

A lad, aged 15, employed with his parents in a travelling show, was in good health until May 12, 1856, when, while playing with another lad, he received a blow on the back with the fist. He thought little of it at the time; but, subsequently, the pain becoming severe, he applied for and obtained admission into Guy's Hospital on May 15. After the application of leeches he was so much relieved that he thought of going out, but the pain soon returned more severely, and fever ensued. An abscess formed on the right side of the sacrum, which was opened, and continued to discharge, the flow of pus being increased by pressure on the abdomen. He continued to get worse daily, having much irritative fever and severe pain in the back. During the last week of his life he was exceedingly restless, and often delirious; and he complained of pain in all parts of his body, but particularly in the extremities. His head was generally drawn backward as in tetanic opisthotonos. On one or two occasions he had loss of power over the bladder and rectum, but had no other symptoms of paraplegia, and could move freely in bed. On June 4 he died, twenty-two days after the casualty, and nineteen days after entering the hospital.

Autopsy.—An aperture in the integuments at the right side of the sacrum led into a very extensive abscess, external to the peritoneum, which occupied the forepart of the sacrum behind the rectum, and extended to the ilia on both sides behind the psoas muscles. The bones were exposed but not diseased. Although the abscess had discharged externally on the right, it was most extensive on the left. It had burrowed up to the left side of the last lumbar vertebra, and through the sacro-vertebral foramen into the spinal canal. When the theca was opened, it was found to contain a quantity of greenish pus, spread over its inner surface and over the cord itself. The spinal dura mater (theca) at the point indicated, was softened and destroyed, and the cauda equina was lying bathed in the pus which filled the sacral canal. The membranes of the cord were inflamed throughout their whole extent, and there was purulent effusion as high as the dorsal region. The spinal dura mater was thickened, its inner surface had lost its smoothness and transparency, and was of a dull-green color. Pus could be squeezed out from beneath the visceral arachnoid in considerable quantity. The spinal cord itself was firm, and the microscope revealed no morbid condition in its substance. On opening the cranium, traces of acute arachnitis were found over the whole surface of the brain, greenish-colored lymph being effused into the sub-arachnoid tissue, especially at the base. The inner surface of the dura mater, around the foramen magnum and on the adjacent part of the occipital fossa, was of a greenish color, from lymph effused upon it. Bronchial tubes filled with tenacious mucus. Lumbar and bronchial glands slightly enlarged. All other organs entirely healthy.³

The purulent infiltration of the spinal meninges which was observed in this case, occurring coincidently with the formation of a lumbo-sacral abscess, but without the production of paralysis, could scarcely have happened unless the sacro-vertebral articulation had previously been opened, both externally and internally, by disease of the articulation itself, in such a manner as to allow the products of inflammatory action to flow freely out of, as well as

¹ Op. cit., pp. 47, 48.

² See pp. 280–303 *supra*.

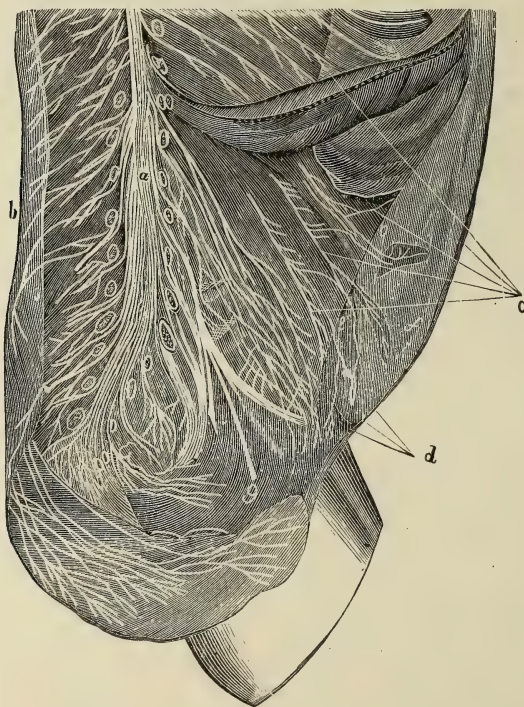
³ Guy's Hospital Reports, 1856, pp. 158, 159.

into, the spinal canal. Otherwise, the suppurative meningitis would pretty certainly have caused paralysis by compressing the spinal cord with the inflammatory products.

The clinical history of this lad's case, interpreted by the post-mortem appearances, appears to have been as follows: The blow on his back wrenched the sacro-vertebral articulation, and caused a suppurative inflammation to be lighted up therein, particularly on the left side, and in consequence of this, purulent matter escaped in an outward direction, and led to the formation of an immense lumbo-sacral abscess; it likewise escaped in an inward direction, and caused the theca vertebralis to become softened and perforated, and extensively destroyed, and a diffuse suppurative inflammation, which extended upward to the brain, to be kindled in the spinal arachnoid. Moreover, the account of the case presented above gives the symptoms by which each of these periods, or stages, in the progress of the case was characterized.

The symptoms indicative of the joint inflammation were pain in and soreness of the joint itself, and these were to some extent relieved by leeching. The

Fig. 898.



Showing the lower part of the spinal cord, and the distribution in the trunk of the corresponding spinal nerves. (Swan.) *a*, The spinal cord. *b*, The posterior branches of the spinal nerves, proceeding to the muscles and integuments of the loins, etc. *c*, The radiating lines indicate the anterior branches of certain dorsal nerves which are distributed to the muscles and integuments of the upper half of the abdominal walls. *d*, The anterior branches of the lumbar nerves which are distributed to the lower part of the abdominal walls. *ee*, Anterior part of the abdominal walls. *f*, The rectus abdominis muscle. *g*, The obturator nerve. *h*, The diaphragm. (Hilton.)

formation of the lumbo-sacral abscess was attended by a return of the joint-pain, followed by pyrexia, and by the appearance of a swelling which, on being opened, discharged purulent matter. The spinal meningitis set in with severe pain in the spinal column, and irritative fever, followed by extreme

restlessness and general hyperæsthesia of a severe character. Tetanic spasms and opisthotonos ensued.

The remote effects of spinal injuries are to be still further traced in the occurrence of *chronic spinal arachnitis* of a fatal character, without the super-vention of any vertebral joint inflammation whatever.

Sir W. Gull has recorded the following instructive case of traumatic, chronic, spinal arachnitis:—¹

A railway porter, aged 22, strong and muscular, had his neck and shoulders squeezed between the buffers of two carriages, on September 20, 1855. For three or four weeks afterward, he was unable to work, and felt much pain in the right arm, as also in the scapular region and down the back, especially between the seventh and tenth dorsal vertebræ. The pain was increased by any sudden twist of the body, and extended to the abdomen. About the first of February, 1856, he was again obliged to quit work, on account of the severity of the pain along the spine. On Feb. 6, he was admitted to the hospital under Dr. Addison's care. There was pain on pressure over the lower dorsal vertebræ, pain in the abdomen, and occasional tingling in the hands and feet. The abdomen itself was full and hard, with pain on suddenly turning the back, extending from the ribs below the umbilicus. Nothing abnormal was found in the chest; pulse 78; tongue furred in the centre; bowels regular; appetite defective. He was treated by cupping, mercurials, and laxatives. On the 11th, the pain in the back was increased. He also had headache, and his nights were restless and disturbed by dreams. The shooting pain in the abdomen continued, and it was noted that the integuments were remarkably hot and dry. The pulse was 72, with a noticeable sharpness in the beat. From this date he became slightly affected by mercurial action, and was apparently improving. He left his bed for several hours in the day, without inconvenience; still, however, complaining of his former symptoms, and of pain through the chest. On the 28th he had general febrile symptoms, with cough, and hurried breathing, and signs of pleurisy at the base of left lung. The abdomen was tense; constipation; pulse 112; sleep disturbed by dreams, and by frequent spasmodic twitchings of the extremities. He complained very much of pain in the lumbar region, on each side of the vertebral column, and down the sacrum. On March 11, there was retention of urine. On the 13th, slight delirium, and a marked decline of strength. He was scarcely able to move his legs, but the sensation on pinching was acute. He lay supine, sinking to the foot of the bed, his arms being too weak to help him to support himself. From this date he rapidly became worse, with much cerebral oppression. The urine drawn off daily by the catheter was ammoniacal, with large deposit of phosphates. The feces escaped involuntarily. Frequent convulsive twitchings, both of the upper and lower extremities. Breathing hurried and laborious. Tongue dry and brown. Pulse 108. On the day before death, he lay nearly insensible, frequently moaning and sighing, pulse 90, feeble and irregular; urine copious, and drawn off by catheter; feces passed involuntarily. On the 17th he died, about six months after the accident.

Autopsy.—No injury of the vertebræ or ribs was discovered; spinal canal and external surface of the spinal dura mater healthy. On opening the dura mater, the spinal arachnoid appeared remarkably thickened and flocculent, from the effusion of lymph beneath it. The effusion was greatest on the posterior surface of the cord along the median line, but at the lower part of the cord (a segment of it corresponding to the lower cervical and eighth upper dorsal vertebræ only was allowed by the friends to be examined), the effusion extended around it to the anterior surface, and upward for a short distance. The cord itself was not softened; and, on repeated microscopical examination of the cord-substance, at different sections, no traces of exudation were discovered. The theca vertebralis had undergone no alteration, excepting that the inner layer was rather opalescent. One or two very small fibroid plates on the visceral arachnoid. The flocculent effusion covering the cord (that is, found in the meshes of the pia mater), presented under the microscope the usual appearances of inflammatory exudation on serous surfaces in the stage of organization into permanent adhesions. Examination

¹ Guy's Hospital Reports, 1856, pp 156, 157.

of head not allowed. Old adhesions over the surface of the upper lobes of both lungs. At lower part of left chest, about a cupful of purulent fluid was found. Parenchyma of both lungs stuffed with softish, yellow, miliary tubercles, equally diffused from apex to base. Kidneys large; their cortical portion studded with miliary tubercles. The splenic tissue similarly affected. Heart and liver healthy.

The phenomena of subacute, traumatic, spinal meningitis, when it runs a chronic course to a fatal termination, are well shown by this case. The symptoms characteristic of the disease were pain in the affected part of the spinal column, increased by suddenly twisting or bending it; also pain felt in the peripheral extremities of all the spinal nerves issuing from the affected part of the spinal column, particularly in the abdomen, in the loins, and in the lower extremities. The abdominal pain was attended with hot and dry integuments, and probably, if carefully looked for, oscillations of temperature would have been observed. These peripheral pains arise from the excitation of the sensory filaments of the corresponding spinal nerves by the inflammatory action that is going on, within the spinal canal, in the membranes of the cord adjoining their roots; for instance, in cases where such peripheral pains are felt at the epigastrium, the sensory filaments of the sixth or seventh dorsal nerves are excited by the inflammatory process in the spinal arachnoid and pia mater investing them before they enter the intervertebral foramina. When the sensory filaments of the eighth or ninth dorsal nerves are irritated in this manner, the peripheral pains are felt lower down in the abdominal walls, in the parts thereof which are supplied by the irritated nerve-fibres; and when the sensory filaments of the remaining dorsal, or of the lumbar nerves, are excited in a similar manner, the peripheral pains are felt still lower down, in the respective terminal extremities of the excited nerve-filaments. Excitation (intra-spinal) of the motor filaments of the spinal nerves arising from the same cause, in this case, was denoted "by frequent spasmodic twitchings of the extremities," by the "tense" and "hard" condition of the abdominal muscles which arose from tetanoid (tonic) spasm thereof, and by the persistently stiff or contracted feeling in the muscles of the extremities, particularly the lower ones, which doubtless was present, and would have been revealed by asking the patient about it.

The altered sensations of the patient in this case, the "tingling" and the "numbness" in his feet and hands, and the acute sensation produced by "pinching" his legs (hyperæsthesia) after paraplegia had set in, were due either to inflammatory excitation of the cord-substance by the contiguous membranes, or to compression of the cord-substance by the inflammatory products effused in the meshes of the spinal pia mater. The vesical paralysis, the alkaline urine, the anæsthesia (insensibility) and motor paralysis (or paraplegia) which appeared near his end, were caused by compression of the cord-substance effected in the way just mentioned.

The inflammatory effusion was found at the autopsy of this case, as usual, under the so-called visceral layer of the spinal arachnoid alone, that is, in the interstices of the pia mater, but principally on the posterior surface of the cord, to which it had probably settled by gravitation. The exudation itself did not contain pus-corpuscles, and would have been capable of becoming organized, if it had not caused death by its quantity, and by the compression which it exerted upon the cord substance. The tubercular infiltration of the pulmonary, renal, and splenic tissues, which was revealed by the autopsy, must be held to have probably resulted from the pathological state of the spinal cord-substance.

But, among the remote effects of spinal injuries, chronic spinal meningitis, combined with *chronic myelitis*, and running their joint course *pari passu*,

must likewise be mentioned. The following example will serve to illustrate the phenomena of traumatic spinal meningitis and myelitis, when they are subacute, and run a chronic course together to a fatal ending.

Sir W. Gull¹ relates the case of a coal wagoner, aged 49, who was forced backward from his seat by striking his head against a beam, whilst driving under an archway; several ribs on the left side were fractured. Some months afterward, he began to suffer pain extending from the occiput down over the shoulders; and, in about a year, the muscles of the upper extremities began to waste. After two years, incontinence of urine gradually came on. He was admitted to Guy's Hospital, February 11, 1857, three years after the accident. He then presented a remarkable example of muscular atrophy without actual paralysis. The upper extremities were principally affected. The extensors of the right hand, the muscles of the thumb, and the interossei were extremely wasted. The wrist dropped. The muscles of the shoulder and arm, including the pectoralis major and minor, were much wasted, but in a marked degree less so than those of the forearm and hand. Very slight diminution of sensation. He could still lift the arm over the head. The left arm was similarly, but less affected than the right, as far as regarded muscular atrophy, but there was numbness through the whole arm down to the fingers, and the patient suffered severely from neuralgic pains in it which greatly depressed him, and which he described as a compound of smarting and numbness. The trapezii, serrati postici superiores, rhomboidei, and all the long muscles of the neck and back, were remarkably atrophied. The spinous processes were very prominent. No deformity nor tenderness on pressure at any point. The intercostals were so weak that the only respiratory movement was through the diaphragm. The supra-spinati were atrophied, but not to the same extent as the infra-spinati and the levatores angulorum scapularum. The legs were wasted and weak, but he was able to walk. Sphincter weak. Dribbling of urine. Constipation. The thorax looked narrow and ill-developed from the wasting of the pectorals, the intercostals, and the erectores spinæ muscles. The muscles of the back of the neck, and the sterno-mastoids, were so weak that the head could not be supported erect. Sight dim; drooping of left eyelid. Frequent hiccough for many months. After admission, his principal complaint was of pain in the left arm from the clavicle to the fingers. He described it as a severe smarting with a sense of numbness. His distress from this cause was very great. Early in March, febrile symptoms set in; tongue became dry and brown; frequent hiccough and vomiting; pain in left arm severe. On March 25th, he died, more than three years after the accident.

Autopsy.—The cranial arachnoid was opalescent, with spots of white, from fatty degeneration, mottling the more opaque parts; subarachnoid fluid in excess; ependyma of lateral and fourth ventricles granular, in the latter extremely so.

The spinal dura mater was much thickened on the posterior surface of the cord; the arachnoid adhered to it in patches along this surface, and was much thickened by the effusion of lymph of an old date. Sections of the cord, examined with the naked eye, gave no distinct evidence of disease. There was a slight yellowishness of the posterior columns, with increased vascularity and thickening of the pia mater covering them. In these columns, but especially in the right one, an abundance of granule cells was discovered by the microscope. The exudation was greatest in the middle and lower thirds of the cervical enlargement. The gray substance was hyperæmic. No exudation into its tissue, nor into the anterior columns. The ventricle of the cord was enlarged and distended with delicate granular nuclei. The affection of the cord appeared to be secondary to chronic inflammation of its membranes, and to chronic changes in the ependyma of its ventricle occurring in common with changes in the ependyma of the fourth and lateral ventricles of the brain. Hypostatic congestion of both lungs, several lobules consolidated from recent pneumonia, some grayish. Other organs healthy.

The phenomena attributable to myelitis which presented themselves in this case were rather peculiar, and consisted of blunted sensibility (anæsthesia), paralysis of the sphincters with obstinate constipation, diminished motility

¹ Guy's Hospital Reports, 1858, pp. 194, 195.

(voluntary-motor paralysis), and muscular atrophy. The hiccough and vomiting, which were frequently observed for many months in this case, were probably dependent upon the origin, distribution, and connections of the phrenic nerves, and arose partly from disease of the membranes, and partly from disease of the cord-substance, in the cervical region.

In regard to the *muscular atrophy*, which was progressive and exceedingly well marked, it also must be looked upon as one of the remote effects of spinal injury, resulting directly, however, from inflammatory irritation of the posterior columns and gray substance of the spinal cord. The attentive reader will doubtless have already observed that, in the case just related, the gray substance was found to be hyperæmic at the autopsy, and that the posterior columns, but especially the right one, exhibited structural changes of a distinctly inflammatory character.

This variety of muscular atrophy was formerly regarded as a primary affection of the muscles themselves. Its origin, however, really lies in certain morbid alterations which have taken place in the gray substance of the spinal cord, particularly the anterior cornua thereof.

I shall next present a remarkable example which will prove very useful in the way of exhibiting progressive muscular atrophy and chronic inflammation of the rachidian substance as remote effects of spinal injuries, such, for example, as concussions of the spinal cord that are thought nothing of at the time when they are received; and, what is of greater importance, it will serve to show how difficult it sometimes may be for even the most skilful observer to make a correct diagnosis as to the essential lesion in such cases. In this example an erroneous opinion was entertained as to the nature of the disease, until this was revealed by the autopsy.

Sir W. Gull has related the following very instructive case of chronic myelitis, involving first, as well as most markedly, the cervical portion of the cord, and arising from concussion thereof produced by a blow on the neck:—¹

A steamboat-stoker, aged 23, intemperate but healthy, was admitted into the hospital, June 5, 1851. Five years before, he had been struck in a pugilistic combat, unexpectedly and severely, "by another man's fist on the side of the neck, near the articulation of the skull with the vertebral column. Since that he has occasionally had difficulty in deglutition, particularly of fluids, which would be expelled through the nose. For the last year he has had a choking sensation; and, at times, difficulty in passing water." Meanwhile, his right arm became weak and wasted, from the shoulder downward, which he ignorantly attributed to an injury of the back of his right hand by the falling of a piece of iron. He continued to work with his left arm for three months longer; but, about 1850, he began to suffer from what he termed "bile," that is, frequent vomiting, unattended by any pain in the head, or giddiness. These attacks of vomiting continued to return for four months; and then, as they subsided, there was increased difficulty of deglutition, and both legs became weak, the left first, and to the greatest degree. In the autumn he improved, and was able to walk about, but the bladder was so far paralyzed that he needed the catheter to be passed for several weeks. The improvement, however, was only of short duration. When admitted into hospital, his right arm was completely paralyzed at the shoulder-joint, and there was great wasting of the muscles; only slight power of moving the fingers remained. There was anæsthesia, increasing toward the hand, but most marked in the branches of the ulnar nerve. No actual paralysis of the left arm, but the muscles were flaccid and weak. He had pains running over the back of his head. He could move his legs slightly. Sensation impaired as high as the hips. No deformity of the spine, nor tenderness on percussion. No sense of constriction at any part of the trunk. Vision somewhat impaired. Urine and feces passed involuntarily. Pulse 90. Tongue clean and pale. He im-

¹ Ibid., 1856, pp. 181-185.

proved, by rest and by the use of electricity, so far that, in October, he could support himself and walk without help, though his gait was very vacillating, from want of power to direct the muscles. No numbness remained in the legs. The right arm continued in the same state as on admission. The left arm was weak, and, at times, he had cramp in the muscles, and involuntary closure of the hand. The sphincter partially paralyzed. Aspect pale and emaciated; the whole muscular system much atrophied. He remained in the hospital until June, 1852, his symptoms fluctuating between improvement and relapse. He could walk about the ward by the aid of a stick, with a feeble gait, his right arm hanging loosely, supported only by the ligaments of the shoulder-joint. In October, 1852, he was readmitted to the hospital. In a few weeks afterward, the left arm was quite paralyzed, and he lost the little remaining power over the sphincters and legs, and became universally paraplegic. He often complained of a sharp pain in the back of the head, and in the upper part of the neck. On January 19, 1853, bronchitis supervened, from exposure in moving him from one ward to another; though trifling in degree, the distress occasioned by it was inexpressible, owing to paralysis of the intercostals [and inability to raise the phlegm by coughing]. A remission of his chest-symptoms occurred until March 14, when they again became aggravated. His distress was indescribable. Ineffectual efforts to expectorate were constantly made; pulse, 120; respiration, 36; face congested. There was complete paralysis of the walls of the chest, as well as of the extremities, and general anæsthesia, yet great pain when the body or limbs were roughly handled (hyperæsthesia). Frequent spasms in the legs; arms not so affected. Urine constantly dribbling. The integuments over the sacrum became slightly abraded, but no slough formed. This patient's miserable existence was protracted until April 12, 1853, nearly two years after he entered the hospital, and seven years after he was injured.

Autopsy.—Remarkable atrophy of the whole muscular system, and of the tissues generally. Pia mater (cranial) and brain-tissue rather watery. On removing the arches of the vertebræ, the whole spinal cord appeared to be large and swollen; in the cervical region the theca was evidently distended by it. The vertebræ and ligaments were not affected. On laying open the theca, there was exhibited a general enlargement of the cervical portion of the cord, which, on transverse section, had an unusual appearance. The columns had a yellowish tint, and were distended by a soft, vascular, translucent growth, parts of which were firmer, and of an opaque-yellow hue. This growth was not defined, but passed insensibly into the degenerated gray substance, which, from the floor of the fourth ventricle to the filum terminale, was pale and swollen, and had much the physical character and consistence of thick boiled starch. This soft starch-like substance, under the microscope, was seen to consist of round, oval, and elongated granular nuclei, imbedded in a slimy blastema. At the filum terminale, where the more normal characters of the gray substance were preserved, these nuclei were scattered amongst the softened tubercles with exudation-cells. The vascular growth in the cervical region consisted of degenerated nerve-tissue, nuclei and nucleated cells, as in the fibro-plastic growths. The opaque part was little else than granular matter and oil-globules. There was no lesion of the membranes of the cord, nor was the continuity of the columns destroyed, though in the cervical region they were spread out, and slightly softened in parts. The nerves arising from the cord in the cervical and lumbar regions, examined microscopically, had the normal structure.

The upper lobes of both lungs contained tubercular masses and scattered tubercles; bronchial tubes dilated; their lining membranes deeply injected and contents purulent. Hepatic tissue congested and fatty. The remaining organs were all healthy.

In this example the spinal meninges were not inflamed (as the autopsy showed), and the symptoms developed were purely those of chronic traumatic myelitis, commencing in the cervical portion of the cord. These symptoms, in general, consisted of a slowly progressive, though somewhat fluctuating, abolition of the functions of the spinal cord. There was progressive sensory and motor paralysis, which, after the lapse of some years, terminated in complete paraplegia. It seems that there was no pain observed until the end drew near, when "complete paralysis of the walls of the chest, as well as of the extremities, and general anæsthesia" had already been established, "yet

great pain" was felt "when the body or limbs were roughly handled." This sort of pain, especially when it is associated with general anæsthesia or sensory paralysis of the parts in which it is perceived, is a not uncommon form of hyperæsthesia, and it arose in the case under consideration either from the inflammatory changes that were occurring in the gray substance of the cord, or from the excitation of the sensory filaments in the adjacent spinal nerves that was caused by inflammation of the cord-substance itself, but probably from the former.

The general atrophy of the muscles of the extremities, observed in the progress of this case before the more distinct symptoms of paralysis appeared, is deserving of special note, as bearing upon the theory of progressive muscular atrophy, many examples of which have no doubt had, contrary to the opinion of those who have recorded them, a spinal rather than a muscular origin. The atrophy of the muscles of the right shoulder, whilst those of the forearm still retained some power, elucidates the seat of the paralyzing lesion in some cases of infantile paralysis of the shoulder occurring during dentition. It has been doubted whether the lesions alluded to have a cerebral or a spinal origin; but their occurrence without any cerebral symptoms, the occasional implication of both arms, or of all the extremities, and the actual observation of a limited spot of ochrey discoloration in the cord, as in one case examined by Cruveilhier, concur with the collateral evidence here afforded in proving a spinal origin for this form of paralysis. (Gull.)

Again, the limitation of the paralysis at its commencement to the right arm, and the preponderating affection of the muscles of the shoulder-joint, are points in the clinical history of this case of great interest in another particular. For, taken together with the injury of his right hand, to which the patient attributed his symptoms, they led to an opinion that the case was one of peripheral paralysis. But such an inference was not supported by the history of the case, nor by the post-mortem appearances of the cord. The slight affection of the muscles of deglutition (paralysis), the sense of choking, and the occasional loss of power over the bladder, which appeared early in the case, established a causal relation between the blow on the cervical part of the spine and the inflammatory lesion of the spinal cord-substance, whilst the peripheral-origin theory of the malady was completely refuted by the normal microscopic structure of the nerve-trunks.

There is nothing more fallacious in practical medicine than hastily inferring a negative from negative evidence, as was clearly shown in this case. The absence of pain on percussing the spine, and the very positive statement made by the patient, that his paralytic symptoms had resulted from an injury of his hand, led to the belief that no morbid process of an active kind was at work in the spinal cord; yet it cannot be doubted that the reverse was the fact. Moreover, the least consideration will serve to show that if the vertebral ligaments, and bones, and joints be healthy, no amount of pressure or percussion, made in the usual way during a clinical examination, can much affect the substance of the cord itself, and that we should base no inference upon the negative evidence thus afforded. Oftentimes myelitis, whether acute or chronic, runs its whole course without the development of any pain whatever, excepting cutaneous hyperæsthesia, discernible, it may be, only by a very careful examination.

The impairment of vision, which was observed in this case, although a minor symptom, is deserving of particular notice. It may be associated, from different causes, with spinal lesions. Here it is probably referable to anatomical changes in the cervical portion of the cord itself, inasmuch as experiments on animals have clearly shown that the condition of the eye is at once affected by injuries to the roots of the cervical nerves.

Vomiting, in persistent, recurring attacks, appeared in this case, as an early sign that the cervical portion of the spinal cord was diseased, and was probably dependent upon the origin and connections of the phrenic nerves. In another case seen by Gull, that belonged to the same category, the symptoms set in with an irritating cough; and "I remember," says the same high authority, "an obstinate case of hicough which, having resisted other treatment, yielded at once to blisters on either side of the cervical portion of the spine, over the origin of the phrenic nerves."¹

The morbid appearances of the gray matter of the cord were peculiar, and probably depended in part upon degeneration of the normal structure, and in part upon a neoplastic formation of the simplest kind. In the cervical region, where the disease began, the morbid process had proceeded furthest, making an approach to the development of a tumor, but not separated by any line of demarcation from the other parts of the gray matter, which had undergone a similar, only a less advanced, change.

More recently, however, the morbid anatomy of progressive muscular atrophy has been studied with great care by MM. Hayem, Charcot, and Joffroy. In M. Hayem's case, death resulted from paralysis of the diaphragm and pneumonia. The lesions revealed by the post-mortem examination pointed to the existence of chronic inflammation of the gray substance of the cord. MM. Charcot and Joffroy were struck in examining the gray substance of the cervical region in their cases, by the extreme degree of atrophy which the cells of the anterior cornua had undergone; a large proportion of them had disappeared so completely as to leave no trace behind. The posterior cornua were unaffected. M. Charcot states that when the alterations are very well marked, the anterior horn of gray matter, which is the seat of the morbid process or the essential lesion, may become considerably reduced in size, and may present a shrunk appearance in transverse section.

But the symptoms of progressive muscular atrophy, when it arises from concussion of the spinal cord, may come on with great rapidity, as was observed in the following instance, which was also reported by Sir W. Gull:—²

A lad, aged 15, received a blow with the fist, between the shoulders, from a boy at play. After a week his head drooped, and from that time the muscles of his upper extremities gradually wasted; the arms dropped and hung useless, the intercostals lost their power, and the breathing was diaphragmatic; the lower two-thirds of the trapezii and the erector spinæ muscles also wasted in the same way.

Fourteen months after the accident, when he tried to stand erect, his head fell forward, and his shoulders were thrown backward to balance it, in the absence of muscular power. He was able to walk, but his gait was vacillating, apparently more from want of muscular power to fix the trunk on the pelvis than from defective power in the legs. He could not sit on a seat without a support to his back. Sphincters unaffected. On testing the electro-contraction of the wasted muscles, by galvanism, they were found to contract in proportion to their mass. No pain attended the progress of the disease; no tenderness of the wasted muscles; no flickering contractions of their fibres.

We now proceed to mention certain *joint-diseases* of spinal origin which must likewise be reckoned among the remote effects of spinal injuries.

(1) M. Charcot has called attention to the *arthropathy* of patients having *locomotor ataxy*.³ Without any appreciable cause we may see, occurring in one night, the development of a general and often enormous tumefaction of the member, most commonly without any pain whatever, or any febrile movement. At the end of a few days, the general tumefaction disappears, but a more or less considerable swelling of the joint remains, owing to the

¹ Ibid., p. 185.

² Ibid., 1858, pp. 195, 196.

³ Lectures on the Diseases of the Nervous System, pp. 79-82. Am. ed.

occurrence of hydrarthrosis; and sometimes to the collection of liquid in the periarticular bursæ also. On making a puncture, a transparent, lemon-colored liquid has frequently been withdrawn from such joints. Ataxic arthropathy usually occupies the knees, shoulders, and elbows; it may also affect the hip-joint. This disorder generally shows itself at a determinate epoch of the ataxy, and its appearance coincides in many cases with the setting in of motor incoördination.

(2) MM. Patruban, Remak, and Rosenthal have observed in *progressive muscular atrophy*, joint-diseases which are closely allied by their clinical features to the arthropathies of ataxic patients. This will not appear surprising, if we remember that a primary or secondary irritative lesion of the nerve-cells of the anterior cornua of the spinal gray substance is the starting point of progressive muscular atrophy. (Charcot.)

(3) Sir W. Gull relates the following highly instructive case of rachidian *concussion*, which was followed by incomplete paraplegia, with redness and swelling of the wrists and ankles, as in acute rheumatism; and, after six months, by recovery:—¹

A medical man, aged 38, inadvertently stepped backward into a hole, a few feet deep, and received a concussion of the spine, on January 22, 1855. After a few days he became partially paraplegic, with weak sphincters; and, at the same time, there came on a diffused redness and swelling of the ankles and wrists. The swelling was not from effusion into the joints, but from œdema of the surrounding tissue. The joints were very painful. The redness and swelling were variable in degree. When most marked, they presented the usual appearances of rheumatism, or rather of gout, for the erythema was brighter, and the œdema more distinct, than in rheumatism. The hands were affected equally with the ankles, though there was no obvious want of muscular power, nor any affection of sensation in the upper extremities; tongue clean; pulse 120; no acid perspiration; urine high-colored, free from sediment, and normal in quantity. The cutaneous nerves generally were hyperæsthetic to a slight touch, but deep pressure gave less inconvenience.

The treatment consisted of good nourishment, wine and brandy freely administered, and opium to allay pain and overcome insomnia. The pulse gradually acquired more power and sank to 80.

The affection of the joints continued in varying degree through March, April, May, and June. From the beginning of April there was an improvement in the power over the legs. The same treatment was continued throughout, without the use of mercurials, local depletion, or counter-irritation. In June, he was able to walk without assistance. During sleep, his hands and feet, wrists and ankles, often became erythematous and swollen. Occasionally, there was formication in the lower extremities. Insomnia was a troublesome symptom from the beginning until the end of the case. In July, he was able to leave the hospital, and to resume his duties as a medical practitioner to some extent.

The disorders, however, which present themselves most frequently as the remote effects of spinal injuries, are chronic spinal meningitis and chronic myelitis. In regard to the symptoms which appear in cases where these two affections coincidently occur, it should be stated that the phenomena which are characteristic of meningeal inflammation will be less and less apparent in proportion as the cord-substance becomes more and more affected by the inflammatory process, and the symptoms of paraplegia, or arrested rachidian functions, will correspondingly predominate. In a case related by Sir W. Gull,² in which the cord-substance speedily became inflamed as well as the spinal membranes, "the patient was unable to leave his bed on account of the weakness of his legs," "within thirty-six hours from the commencement

¹ Guy's Hospital Reports, 1858, pp. 199, 200.

² Ibid., 1856, pp. 154, 155.

of the disease;" and, when admitted to the hospital, "on the ninth day from the commencement of his symptoms," "there was complete loss of motion and sensation. It was also remarkable how entirely the functions of the brain were undisturbed throughout, contrasting strongly in this particular with a large proportion of the recorded cases of acute spinal meningitis." These differences are easily explained by the extent of the injuries or by the other conditions which engender the disorder, and by the patient's temperament, the extent of the disease itself, and the actual presence of disease in the brain or its membranes.

Treatment.—In all these cases, uninterrupted rest in bed is a remedial measure of great importance. Ergot should be perseveringly administered in full doses, with a view to control the congestion of the spinal cord and its membranes which is present in almost all of them. Potassium iodide and the corrosive chloride of mercury should be given, together or separately, with a view to dispose of the inflammatory products. In cases tainted with syphilis, these remedies will often prove singularly useful, as I know from experience. Counter-irritation should be made over the spinal column with dry-cupping, setons, or the actual cautery. The latter especially has often been found to do much good in such cases. Progressive muscular atrophy requires the employment of the primary galvanic current to the spinal cord itself, from above downward, and of the faradic current to each of the wasted muscles.¹

RAILWAY-INJURIES OF THE SPINE are, as a group, characterized by the coincident occurrence of sprains, wrenches, or twists of the vertebral column, stretching of the spinal membranes—particularly the theca—corresponding thereto, and profound concussion of the rachidian substance. Hence, in such cases there may coincidentally appear inflammation of the vertebral joints, inflammation of the spinal membranes, and inflammation of the rachidian substance. Moreover, in these cases there is always peculiar difficulty experienced in determining the full extent of the damage—difficulty which is often increased very much by the absence of all external evidence of physical injury, by the obscurity and insidious character of the early symptoms, by the slowly progressive development of the secondary organic lesions, as well as of the functional derangements produced by them, and by the uncertainty which surrounds the ultimate issue. They therefore constitute a class of injuries which often severely tax the surgeon's diagnostic skill and therapeutic resources.

The nature and peculiarities of railway-injuries of the spine can be most clearly shown by presenting an example:—

Mrs. J. C. F., aged 31, and married, consulted me on March 11, 1881, in regard to the effects of injuries which she had received in a railway-collision, on Christmas-eve, something more than two and one-half months before. While seated in the rear portion of a railway car, she suddenly saw that a collision was inevitable, and sprang to her feet, and was therefore standing when the cars collided. She was terribly shaken up and wrenched in the loins, as well as thrown about, and felt stunned, cold, and faint. There was so much depression from "shock" that a druggist administered ammonia to excite reaction. She was in perfect health when the accident occurred, but has not seen a well moment since that time. Next day, she felt lame and sore "all over," and had severe pain in the lumbar region, which was increased by motion, and pain in the left hip. The pain in the loins and left hip continuing eight days after the accident, she sought for relief at the Woman's Dispensary, when tincture of iodine appears to have been applied to the painful hip, but without doing any good whatever. At this time she had a miscarriage, being, as she thinks, about two months advanced in pregnancy. March 11. She says that she has not been free from the pains above mentioned

¹ See also what has already been said concerning the treatment of the acute and subacute forms of traumatic spinal meningitis and myelitis.

since the accident; has now much distress in the cervical and dorsal, as well as in the lumbar portion of the spine; the pains extend from the left loin and hip downward into the left thigh and knee; has also much pain extending from the spine into the left arm, and numbness in the parts supplied by the ulnar nerve (little finger and adjacent side of ring finger); has lost much flesh; is very weak and nervous, and has been so ever since the accident; often has cardiac palpitations so marked that she is afraid to go into the street alone; pulse frequent (about 100), and rather weak; countenance anæmic, and expressive of great suffering; tongue clean; bowels regular; appetite and digestion good, but her food does not seem to benefit her; she suffers much from insomnia, for the pains in her spine, left hip, and left extremities, both lower and upper, keep her awake; the lumbar part of the spine, especially the left side thereof, exhibits tenderness under pressure. I prescribed the bromides of potassium, sodium; and iron, in full doses, with rest as nearly absolute as possible, and counter-irritation to be applied over the whole spinal column; and I hoped that, as the inflammation of the wrenched vertebral articulations should subside under this treatment, the symptoms of meningo-rachidian irritation would likewise disappear.

July 21. She is no better; is much emaciated (weighing but 103 lbs., while her usual weight is 119 lbs.); is pallid, and looks wan, wearied and prematurely old; has much distress in the head, with a sore feeling in the scalp, and rapid falling of the hair; pains in the spine and left hip continue severe, and involve the whole of the left upper extremity, as well as the whole of the left lower extremity; pains sometimes shoot down into her left leg and foot; has no pain in the right extremities; suffers great distress at the bottom of her back, across the sacrum (sacrodynia), and when her back is worse her distress in the head is more severe; she also has formication, a "pins and needles" feeling, and a sensation of numbness or as if the parts were asleep, in all of her left side, and in her left hip, but especially in the left foot and leg; has likewise a "pins and needles" feeling in the left hand and arm, but not as much as in the left lower extremity; has a constricted or "tight-belt" feeling which extends around her body; the muscles of her left leg and thigh often feel stiff; her pains and abnormal sensations are always made worse by getting tired; during the last two months, exercise, or a sense of fatigue, always brings on nausea, and sometimes vomiting; feels sick at the stomach this morning in consequence of walking to my office; lies in bed on her left side, because she gets more ease in that position; has often to get up at night and rub the affected parts on account of the "pins and needles" feelings, and sensations of numbness; is very restless at night, and scarcely ever sleeps more than two hours at a time; menstruation irregular and deficient; she also has much thirst and "inward fever;" pulse about 100, and feeble; tongue clear, bowels soluble. Potassium iodide, in ten grain doses, three times a day, was ordered as a remedy against the spinal meningitis and myelitis which were obviously now present, with syrup of the hypophosphites of lime and sodium as a tonic; counter-irritation over the left hip and the whole length of the spinal column, to be continued, with rest in bed; but unfortunately her circumstances in life were not such that the last-named remedial measure could be carried out as thoroughly as was desired.

October 2. Her case became complicated with an attack of malarial fever, which was promptly subdued by the administration of quinine.

March 21, 1882. She is somewhat better, but her eyesight is impaired; says that after resting in bed for a time, she always gets better; but, as soon as she begins to go around again, especially if she tries to work, she again gets worse. In addition to potassium iodide, syrup of the iodide of iron, *gtt. xv.*, three times a day, was prescribed.

June 12. I was called, and found her suffering very much from coccygodynia; the sacro-coccygeal articulation was inflamed, and so much damaged that the coccyx was quite movable, as well as bent forward at nearly a right angle; her general symptoms, however, were upon the whole rather better.

June 15. Professor Wm. A. Hammond saw her in consultation. Her weight is now 99½ lbs.; it used to be 119 lbs.; the headache continues, and her eyesight is very much impaired; she has difficulty in holding her urine, which is normal in appearance; makes it too often, and has to run in order to avoid wetting herself (vesical hyperæsthesia); has pain in the lumbar, sacral, and coccygeal regions all the time, and it is always aggravated by exertion. There is much tenderness under pressure along the

left side of the dorsal and lumbar vertebræ, and over the whole of the sacrum; the head of the coccyx is displaced forward, and crepitus can be felt in the sacro-coccygeal joint; tenderness about the lower end of sacrum and coccyx much complained of by the patient; besides pain, etc., she says she has a "stiff feeling" in the muscles of the left thigh and leg, which is worse at some times than at others; says she also feels constricted around her bowels, as if her clothes were too tight, or as if a belt were tightly drawn and buckled around her bowels, and has had this feeling for a long time. The æsthesiometer showed that cutaneous sensibility in the left thigh was less than normal. In addition to syrup. ferri iodid., which she was now taking, fluid extract of ergot in full doses was prescribed, with strong counter-irritation over the sacrum.

December 6. Upon the whole she is much better. The sacro-coccygeal pain is greatly lessened, and ankylosis of the joint appears to have occurred, with the coccyx bent forward and somewhat to the left at a right angle. Her eyesight, however, is very much impaired. The vesical hyperæsthesia, too, has returned, and gives much trouble, for she has to make water every few minutes. Ordered extract of belladonna gr. $\frac{1}{4}$, ergotine, gr. iiss., to be taken in pilular form three times a day; in four days the vesical reflex became normal. Also advised the belladonna and ergotine to be taken for a fortnight longer, and to be followed by potassium iodide.

The internal remedies which did this patient most good were ergot, belladonna, and potassium iodide; and the benefit derived from their administration was very evident.

The spinal lesions in this case were mostly unilateral; and, as a rule, involved the left half of the column only. The spinal articulations which became inflamed were certain of the lumbar, as well as the lumbo-sacral, and the sacro-coccygeal. The pain felt in the dorsal and cervical parts of the spinal column, and in the left arm, forearm, and hand, was due entirely to spinal meningitis. The pain in the head and the impairment of vision, which came on afterwards, were probably due to extension of the inflammatory process from the spinal to the cerebral membranes. The pain in the lumbar vertebræ, sacrum, and left lower extremity, was caused in part by spinal meningitis, and in part by inflammation of the vertebral joints. The sensations of numbness, or as if the limb were asleep, of formication, of "pins and needles," of constriction around the body as if it were tightly belted, and the cutaneous anæsthesia, arose from myelitis. The vesical hyperæsthesia probably arose from rachidian hyperæmia and irritation, whereby the urinary bladder's reflex centre became unduly excited. At least, such was my diagnosis; and, on administering ergot to subdue the rachidian hyperæmia, and belladonna to allay the vesical reflex excitation, relief was promptly obtained. The nausea and vomiting which at one time were brought on by any slight muscular effort, also indicated that the cervical portion of the spinal cord-substance was inflamed. This woman, almost two years after the accident, although much improved in health, is not yet well again, for she is still suffering from inflammation of the spinal cord and its membranes. Moreover, there is much doubt as to whether she ever will entirely recover.

The phenomena which present themselves in cases where spinal injuries, without fracture, are caused by railway-collisions, result, as already intimated, from the severe wrenches and twists which the vertebral joints have sustained, or from the violent stretching and hemorrhagic infiltration to which the spinal membranes have been subjected, or from the more or less profound concussion, and perhaps contusion, of the substance of the spinal cord itself, or from the combined influence of all these lesions. We shall not be surprised to find that such grave consequences may be engendered by railway-collisions, if we reflect for a moment upon the nature of these accidents. It must, I think, be evident to all that, in no ordinary accidents can the shock, both physical and mental, be nearly as great as in those which occur in the collisions of railway-cars and engines. The swiftness of the movement, and the extraordinary momentum of the persons injured, as well as of the vehicle

which carries them, the suddenness of its arrest, and the helplessness of the victims, are all circumstances which of necessity greatly augment the severity of the injuries sustained by the spinal column and cerebro-spinal axis. But perhaps there is one circumstance which more than any other gives a peculiar character to railway-collisions, namely, the thrill or jar, the "*ébranlement*" of French writers, the sharp vibrations, in fact, which are transmitted to everything that is subjected to the force of such collisions. It is this vibratory shock or jar, which by some is compared to an electric shock, by others to setting the teeth on edge (Erichsen), that causes railway carriages to be shattered into splinters on colliding, and produces the sharp tremulous movement which runs through every structural fibre of the occupants, whereby profound concussion or contusion of their spinal cords is oftentimes effected. Moreover, the body of the passenger is simultaneously pitched about or hurled to and fro, not unfrequently five or six times, without there being any power of resistance or of self-preservation, and thus the vertebral articulations are often severely wrenched, as well as the spinal membranes severely stretched and irritated.

Those injured by railway-collisions may sustain dislocations and fractures of the vertebræ, lacerations of the spinal meninges with intra-vertebral hemorrhage, and lacerations of the substance of the spinal cord with intrarachidian hemorrhage. It is not, however, my purpose to devote now any time to the discussion of these lesions, for they differ in no wise from those produced by falls and blows, which have already been fully considered in the foregoing pages. Likewise, acute inflammations of the spinal membranes and spinal cord may arise from the injuries occasioned by railway-collisions. These disorders have also been so fully discussed above, that it is now unnecessary to take them up again. We are at present chiefly concerned with the *remote effects* of the spinal injuries which result from railway-collisions, such, for example, as chronic inflammation of the vertebral joints, chronic spinal meningitis, and chronic myelitis, together with the structural changes, and functional disturbances, or phenomena, by which these affections are severally attended. And, inasmuch as chronic vertebral arthritis with caries and necrosis, chronic spinal meningitis, and chronic myelitis, when they present themselves as the remote effects of spinal injuries caused by railway-collisions, differ in no essential particular, with regard to anatomical changes, functional disturbances or symptoms, and therapeutic indications, from the corresponding affections of the spine which are not unfrequently produced by blows on the back and various common accidents, the discussion of which has just been ended, I shall not occupy much space in any further discussion of them.

In respect to the symptoms by which the remote effects of spinal injuries caused by railway-collisions are characterized, they will be found to vary according as the inflammatory lesions of the vertebral articulations, of the spinal membranes, or of the spinal cord-substance, may predominate. For instance, in cases where myelitis constitutes the principal secondary lesion or disorder, cutaneous anæsthesia and complete paraplegia, with alkaline urine, etc., often combined with hyperæsthesia, will probably be observed at an early period; while in others, where meningeal inflammation constitutes the main affection, there will be marked cutaneous hyperæsthesia with severe peripheral pains, as well as intense pain in the spinal column itself, combined perhaps with tetanic spasms of the posterior cervical, abdominal, and other muscles, but without any paralysis whatever of the voluntary muscular apparatus.

As Mr. Erichsen well remarks, one of the most remarkable phenomena of this class of cases is, that, at the time of the accident, the victim is often quite

unconscious that he has received any serious damage. He feels that he has been violently jolted, and shaken; he likewise feels, perhaps, somewhat giddy and confused, but he finds no bones broken, merely some superficial cuts or bruises, and possibly even no external evidence whatever of injury. He congratulates himself upon his escape from the imminent peril to which he has been exposed, and gives valuable aid to his less fortunate fellow-passengers for several hours. But, when he reaches his home, the effects of the injury which he has sustained begin to manifest themselves. He bursts perhaps into tears, and becomes unusually talkative, as well as excited. He cannot sleep, or, if he does, he suddenly wakes with a vague sense of alarm. Next day he complains of feeling shaken or bruised all over, or as if he had been beaten, or had violently strained himself by exertion of an unusual kind. This stiff, strained, and sore feeling chiefly affects the muscles of the loins and neck, but sometimes involves also those of the thighs and shoulders. After a time, which varies in different cases from a day or two to a week or more, the victim finds that he is unfit for exertion and unable to attend to business. He now lays up, and perhaps for the first time seeks surgical assistance. (Erichsen.) His countenance becomes pallid, wrinkled, and acquires a care-worn or anxious expression; and he generally looks much older than he really is, or than he did before the accident. Some time subsequently, and possibly long afterward, the symptoms mentioned above, of spinal meningitis and myelitis, present themselves; and these grave disorders run their destructive course, unless they are fortunately arrested by timely treatment.

Pathological Anatomy.—As far as I know, there is but one case on record in which, death having ensued as a remote consequence of spinal lesions arising from a railway-collision, the morbid state of the spinal cord and its membranes has been accurately determined by a thorough post-mortem examination. The history of this highly important case is briefly as follows:—

A man, aged 52, and of active business habits, was the subject of a railway-collision. Immediately after it he walked from the train to the station near by. He received no contusions, nor wounds, nor any external sign of injury; but he did complain of pain in his back. He strove hard to keep up, and at his business, and did so for a short time after the accident, although with much distress. Numbness and want of power in the muscles of his lower limbs appeared, and gradually but steadily increased; thus he soon became disabled. His gait became unsteady, and like that of a semi-intoxicated person. There was also extreme sensitiveness to external impressions, so that a shock against a table or chair gave him great distress. The paralytic symptoms came on in less than one year after the accident. In the latter part of his illness, some weakness of his upper extremities became apparent, so that, when he was off his guard, a cup or a glass would slip from his fingers. He could barely walk with the aid of two sticks; and at last he was confined to bed. His voice became thick, and his articulation imperfect. There was no paralysis of the bladder until about two years after the accident, when his urine became pale and alkaline, with muco-purulent deposit. He died three and one-half years after the accident.¹

Dr. J. Lockhart Clarke carefully examined the spinal cord and membranes, which were obtained at the autopsy of this case, and reported upon them as follows:—

“I found that the membranes at some parts were thickened, and adherent at others, to the surface of the white columns. In the cord itself, one of the most striking changes consisted in a diminution of the antero-posterior diameter, which, in many places, was not more than equal to half the transverse. This was particularly the case in the upper portion of the cervical enlargement, where the cord was consequently much flattened from behind forward. On making sections, I was surprised to find that of all the

¹ Erichsen, On Concussion of the Spine, etc., pp. 178, 179. 1882.

white columns, the *posterior* were exclusively the seat of disease. These columns were darker, browner, denser, and more opaque than the antero-lateral; and when they were examined, both transversely and longitudinally, in their preparations under the microscope, this appearance was found to be due to a multitude of compound granular corpuscles, and isolated granules, and to an exuberance of wavy fibrous tissue disposed in a longitudinal direction. It was very evident that many of the nerve-fibres had been replaced by this tissue, and that at certain spots or tracts, which were more transparent than others, especially along the sides of the posterior median fissures, they had wholly disappeared. Corpora amylacea also were thickly interspersed through the same columns, particularly near the central line. The extremities of the posterior horns contained an abundance of isolated granules like those in the columns, and in some sections the transverse commissure was somewhat damaged by disintegration. The anterior cornua were decidedly smaller than natural, and altered in shape, but no change in structure was observed.²¹ Dr. Clarke remarked that the alterations in appearance presented by the cord, in this instance, bore a striking resemblance, in the limitation of the principal lesions to the posterior columns, to what is met with in locomotor ataxy.

The post-mortem examination of this case also revealed traces of chronic inflammation in the cranial arachnoid membrane, and in the cortical substance of the brain.

From the foregoing account of this case, it appears that the injuries caused by the railway-collision eventuated in chronic hyperæmia and chronic inflammation of the spinal arachnoid membrane and spinal cord-substance, especially the posterior columns thereof, which slowly spread upward until finally the morbid process involved the encephalic arachnoid membrane, and the cortical substance of the brain. Moreover, there is good reason to believe that when the inflammatory process attacks other portions of the spinal cord in cases belonging to this category, it is capable of producing progressive muscular atrophy, and other important consequences, which have been mentioned above.

Brief mention must here be made of some rather important complications which present themselves with great frequency in cases where spinal injuries have been produced by railway-collisions without luxation or fracture.

(1) *Impairment of Vision.*—One of the most frequent and troublesome among the remote effects arising from injuries of the spine, especially those received in railway-collisions, is diminution of the eye-sight. As a rule, this complication is met with only in cases where there is traumatic inflammation of the spinal cord and its membranes, which pursues a chronic course. For instance, it presented itself some considerable time after the accident in the case of Mrs. J. C. F., which has been related above. On examination, I found her eyeballs sunken, flattened, watery, and dull in appearance, and looking like the eyeballs of a much older person. The pupils were contracted to one-half the normal size, and were also sluggish. She complained that her eye-sight had become weak and dim. There was no diplopia, but objects appeared to her to be enveloped by mist or fog. At one time, she had black spots floating in the field of vision. The veins of the eyeballs were dark-purple, and distended with blood. Her vision was much better on some days than on others; for example, it was much better on bright than on dull days. She could not see except in a good light.

This subject has been carefully investigated by Mr. Wharton Jones and Dr. Clifford Allbutt. The former states that the pupils are usually half-closed, the eyes sunken, dull, and watery, and the veins of the eyeball congested, which abnormal appearances were all noted in the case recorded by myself. He also states that the movements of the pupils are sometimes

²¹ Transactions of the Pathological Society of London, vol. xvii. p. 21.

normal, sometimes sluggish, and sometimes abnormally active. They are sluggish in cases of asthenopia, but abnormally active in cases where there is intra-ocular hyperæmia or inflammation.¹

The ophthalmoscopical appearances presented by cases of spinal disease or injury have been described by Dr. Allbutt, as well as by Mr. Wharton Jones. Dr. Allbutt finds that they may all be classed under two heads:—

“1. Simple or primary atrophy of the optic nerve, sometimes accompanied at first by that slight hyperæmia and inactive proliferation which make up the state I have called chronic neuritis. This sort of change I have never found as a result of spinal injuries, but I have often met with it in chronic degeneration of the cord and in locomotor ataxy. 2. A somewhat characteristic hyperæmic change, which I have not seen in chronic degeneration, nor in locomotor ataxy, but in cases of injury to the spine only. The retinal arteries do not dilate, but become indistinguishable; while the veins begin to swell, and become somewhat dark and tortuous. The disk then becomes uniformly reddened, and its borders are lost, the redness or pinkness commencing with increased, fine vascularity at the inner border, which then invades the white centre and the rest, so that the disk is obscured, or its situation known only by the convergence of the vessels. In many cases, rather than redness, I have observed a delicate pink—pink which sometimes passes into a daffodil color. In one case in particular—a railway accident—which I examined in consultation with my friend and colleague, Mr. Teale, this daffodil color of the whole field was very curious; no disk was to be distinguished, but the dark vessels stood out in beautiful relief. The other eye presented the common appearances of hyperæmia and serous effusion, with slight swelling. It is to be remarked that this state is generally or always of long duration; it passes very slowly up to its full development, and then shows a disposition to end in resolution rather than in atrophy. In those cases which I have been able to watch diligently for many months, the pinkness seems slowly to have receded, leaving an indistinct but not very abnormal disk behind. Sometimes the sight suffers a good deal in these cases, sometimes but little or scarcely at all. I have never seen true optic neuritis, with active proliferation, as a sequel of spinal disease.”²

Dr. Allbutt states that in thirteen cases of chronic spinal disease following accidents, he found disturbance of the optic disk and its neighborhood in eight instances, and that the disturbance of the eye “is seen to follow disturbance of the spine with sufficient frequency and uniformity to establish the probability of a causal relation between the two events.” But, in the more severe forms of spinal injury, those, for example, which prove fatal in a few weeks, these evidences of ophthalmic disease are not met with; for, in seventeen cases of this sort, Dr. Allbutt found no evidence of ophthalmic disease in any instance.

To what should the impairment of vision in question be ascribed? The same eminent authority holds “that hyperæmia of the back of the eye, following injury to the spine, is probably dependent upon a greater or less extension of the meningeal irritation up to the base of the brain. Now, have we any reason to suppose that spinal meningitis does creep up into the encephalon? We have: For, setting aside the curious head-symptoms such patients often present, here the actual demonstration of autopsy comes to our aid. It is tolerably well known to careful pathologists that encephalic meningitis is a very common accompaniment of spinal meningitis.” Moreover, in a number of instances presented in the foregoing pages, the post-mortem examination revealed the fact that inflammation of the spinal membranes had extended upward until it likewise involved the encephalic membranes. I have no doubt that the ophthalmic lesions above mentioned are solely due to the creeping upward of a chronic meningitis which originally is spinal, but in the end becomes cerebral also.

¹ On Failure of Sight after Railway and other Injuries, p. 44.

² *Lancet*, 1870, vol. i. pp. 76, 77.

(2) *Impotency*.—Mr. Erichsen states that *priapism* does not occur in cases of spinal concussion resulting from railway-collisions, and that, as a rule, the genitals are quite flaccid in such cases.¹ This statement, however, does not hold good in those concussions of the spinal cord which are attended with contusions of the rachidian substance, or with intra-rachidian extravasations of blood; for there was well-marked priapism in several instances of this sort which have been mentioned in the preceding pages.

Mr. Erichsen likewise states that *sexual desire* and *sexual power* are usually greatly impaired, and often entirely and permanently lost, in consequence of spinal injuries arising from railway-collisions, and Mr. Humphry has seen a case of complete impotence consequent on a jar to the spine thus caused.² This, however, is not invariably the case; for the wife of one of Mr. Erichsen's patients miscarried twice during the year succeeding her husband's injuries.³ There is, however, no doubt, I think, that the spinal injuries produced by railway-collisions usually inhibit for a time, and often completely and permanently destroy, the sexual reflex centre in the spinal cord. In this manner, such injuries frequently give rise to impotency.

(3) *Sacrodynia*.—The group of symptoms arising from spinal injuries received in railway-collisions, to which Mr. Erichsen with much propriety has given the name of *sacrodynia*, consists of the following: Soon, but not of necessity at once, after the accident, the patient feels a diffused pain over the entire sacral and sacro-lumbar regions. It is usually most intense over the sacrum, and especially over the sacro-iliac synchondrosis. It is, however, not confined to this part; for it extends upward as high as the fourth or third lumbar vertebra, and laterally, perhaps, almost to the trochanters. But the sacrum is the focus of its greatest intensity. When the sacro-iliac junction also is the seat of suffering, it is the left that is affected in a large majority of instances. Over the whole of this region there is tenderness under pressure, and the pain is greatly increased by movements of all kinds. There is no nocturnal exacerbation. There is no external sign of injury in the way of swelling, heat, or discoloration. The patient cannot stand erect without increasing the pain; hence, a tendency to stoop slightly forward, and perhaps to incline to one side, is exhibited. Advancing the lower extremities greatly increases the pain; the patient, therefore, walks with difficulty, takes short steps, leans on a stick, and, when one side is more painful than the other, drags the leg on that side. As already stated, the left is much more frequently the painful side than the right, and hence it is that the left leg is so frequently "dragged" in these cases. The greater frequency and the greater severity of *sacrodynia* on the left side, than on the right, and the consequent dragging of the left leg, are very notable circumstances. They occur in at least three-fourths of all the cases. My patient, whose case has been related above with some particularity, suffered dreadfully in this way. The great preponderance of left-sided cases of *sacrodynia*, is probably to be explained by the fact that most people are right-handed, and that in consequence thereof they instinctively put forth their right hands for self-protection when they are pitched about the cars in railway-collisions, and at the same time correspondingly advance the right side of their bodies, which of course places their left buttocks and the left side of their sacral bones in a position to bear the brunt of blows received from behind. At all events, I believe this to be the true explanation of the left-sided *sacrodynia* with which my patient was afflicted. In her case, too, there was so much traumatic inflammation of the sacral ligaments, that the sacro-coccygeal articulation was destroyed by it, and ankylosis of that joint with the coccyx in an abnormal position ensued.

¹ Op. cit., p. 64.

² Op. cit., p. 172.

³ Holmes's System of Surgery, vol. v. p. 161, foot note.

The symptoms of sacrodynia often continue for a long time. When once they have fairly set in, they will last for many months, and not unfrequently for a year or two. Moreover, the pain does not follow the anatomical course of any nerve, and, therefore, it cannot be classified with the neuralgias. It appears to arise directly from bruising and spraining of the ligamentous structures. The sacro-vertebral, the ilio-lumbar, the sacro-iliac, and the sacro-ischiatic ligaments may all be more or less strained in the bumps, twists, and wrenches to which the pelvis and lower part of the spine are subjected in the accidents under consideration. And, according as the violence falls more or less directly on one or other of these ligaments, so the patient will suffer more or less in the part where it is situated. (Erichsen.) The long continuance of pain in cases of sacrodynia is exactly what we find in cases where the ligaments are strained in other parts of the body.

(4) *Vomiting*.—It will be remembered by some that about twenty-five years ago Sir W. Gull, in Guy's Hospital Reports, called attention to vomiting as a symptom or effect of hyperæmia or inflammatory irritation of the rachidian substance in the cervical region, and recorded an example in which the existence of myelitis in the cervical region (caused by a blow on the neck) was proved by post-mortem examination. This case I have used above to illustrate the remote effects of spinal injuries. It will likewise be remembered that any slight muscular effort on the part of my own patient who suffered from railway-injury of the spine, and whose case I have so often referred to, always produced nausea, and sometimes caused vomiting, and that these symptoms of cervical myelitis lasted for several months. Mr. Erichsen,¹ too, relates a very instructive case in which concussion of the spinal cord caused by a blow on the nape of the neck received in a railway-collision, and the rachidian inflammation which ensued, were attended by vomiting as a prominent and a very persistent symptom. It is obvious that medication for the relief of this symptom, in such cases, should be directed towards the removal of its cause, namely, the rachidian hyperæmia and irritation in the cervical region, upon which its existence depends.

Treatment.—Inasmuch as the spinal injuries arising from railway-collisions may be followed by inflammation of the vertebral articulations, inflammation of the spinal membranes—but particularly of the spinal arachnoid and pia mater—and inflammation of the rachidian substance, the first step consists in making, as far as practicable, a differential diagnosis. Almost always, in such cases, spinal meningitis and myelitis will be found creeping up the cord together into the cranium; and, not unfrequently, all three disorders will simultaneously present themselves. The principles upon which the treatment of each of these inflammatory affections of the spine, whether acute or chronic, should be conducted, have already been laid down, and the several remedial measures which experience has shown to be the most useful in such cases, have already been mentioned; it does not seem necessary to restate them here. One thing, however, I will say, namely: The importance of rest in bed, in these cases, cannot be overestimated. Furthermore, insomnia occurring *per se*, that is, without pain, should be overcome by administering the bromides or chloral hydrate rather than opium or morphia; but pains in the spinal membranes, ligaments, or joints must be subdued by exhibiting the last-named drugs. When the morbid process in the rachidian substance has reached the stage of atrophy, the primary galvanic current passed downward through the cord may prove very useful. But whatever the treatment may be, no speedy benefit can, as a rule, be expected.

¹ Op. cit., pp. 216-219.

[ADDITIONAL REMARKS ON RAILWAY-INJURIES OF THE SPINE.]

Mr. Gore's case, quoted from Mr. Erichsen, on page 479, has been much relied upon by surgeons called as expert witnesses for the plaintiff, in suits for damages against railway companies, as showing the grave and well-defined lesions of the spinal cord, which may follow in instances of what is ordinarily called "spinal concussion;" and it has, on the other hand, been subjected to sharp criticism by experts for the defense, in such suits, on the ground that it stands alone, and that the lesions observed were possibly due to ordinary locomotor ataxia, and not really caused by the accident which preceded their development. It is to be observed, however, as pointed out by Mr. Jacobson in the third edition of the "System of Surgery," edited by Messrs. Holmes and Hulke, that unmistakable cord-lesions, only recognizable by the microscope, have also been observed in cases of spinal "concussion" due to other than railway-injuries. Thus, in the case reported by Dr. Bastian in the 50th volume of the *Medico-Chirurgical Transactions*, and quoted by both Jacobson and Page (by the former incorrectly attributed to Dr. Gowers), the patient lived nearly six months after falling, while asleep, twenty-five feet from the top of a hay-rick; at the post-mortem examination, the vertebræ were found uninjured, and to the naked eye the spinal cord appeared perfectly healthy. Under the microscope, however, ruptures of varying size were found in the right and left halves of the grey matter of the cervical cord, and distinct areas of degeneration in the anterior columns of the cervical, dorsal and lumbar cord, best marked above. Similar, but less extensive, areas were also found in the left lateral column. Beside the descending lesions of the anterior and lateral columns, there was ascending degeneration in the posterior columns of the upper cervical cord and medulla.

This case is reported by its observer, and accepted by Mr. Jacobson, as one exhibiting typical "concussion-lesions," but Mr. Page (whose excellent work, "Injuries of the Spine and Spinal Cord without apparent Mechanical Lesion," etc., appeared after Dr. Lidell's article had been completed), objects to the term "concussion" as applied to injuries of the spinal cord, and points out that though Dr. Bastian referred to the case as one of concussion-lesion, such as might be met with after railway-collisions, no record of any case at all comparable with it has been published since. Mr. Page maintains, and my own experience disposes me to agree with him, that in certainly the very large majority of severe spinal injuries received in railway-collisions or by similar accidents, there is found some tangible lesion, recognizable during life, such as a twist or sprain of the vertebral articulations, or a rupture, partial or complete, of the spinal nerves; and he believes, with Le Gros Clark, that the milder cases, in which recovery often follows after some months or years, are attributable to general "shock to the nervous system" rather than to any condition peculiar to the spinal cord. I see myself no objection to the term "spinal concussion," and believe that the spinal cord may, as the result of severe shaking and knocking about, as well as from falls or other forms of diffused violence, be the seat of such lesions as are acknowledged to be present in the brain in cases of cerebral concussion—slight and quickly recovered from in most instances, but under other circumstances more severe, and followed by inflammatory or degenerative changes which may cause prolonged disability or even death. At the same time, there can be no doubt that in many cases of so-called "railway-spine," the condition is a general one, affecting the whole nervous system, and more

analogous to certain examples of what, for want of a better name, we call hysteria, than to any local affection. The suffering in these cases may be really quite as severe as in more dangerous conditions, and though the prognosis may be more favorable, the patient's disability is, for the time at least, indisputable. "It is all very well to say," remarks Mr. Page—"and it is an easy enough diagnosis to make—that so-and-so, who recovered as soon as his claim was settled, was 'shamming,' and that his symptoms were altogether untrue or wilfully exaggerated; but this will hardly suffice, nor can we accept it, to explain the symptoms which have caused so much anxiety and trouble, and have been so little amenable to treatment. The man recovers quickly because the goal, whose prospect unsettled him, has at length been reached, and because it no longer stands in the way of his making the requisite and successful effort to resume his work."

Mr. Page refers to some interesting cases reported by Mr. Bruce-Clarke in the sixteenth volume of St. Bartholomew's Hospital Reports, which show that not only do well-marked changes in the optic disc often accompany injuries in the upper part of the spinal cord, but that, in cases which end in recovery, these changes—hyperæmia and œdema—may be only transient; and the inference is therefore reasonable that similar changes may exist at some period in many cases of minor spinal injury, and are not detected simply because they are not looked for at the right time.

RESECTION OF THE SPINE.

On page 379, reference has been made to the statistics of spinal trephining or resection collected by the Editor. To the 41 cases there mentioned, nine examples of the operation have been recently added by Stemen (two cases), Pinkerton, Halsted, Macewen, Lucke, Albert, Lauenstein and R. T. Morris, so that the figures now stand as follows:—

Whole number of cases	.	.	.	.	.	50
Patients died	.	.	.	.	.	33 or 66 per cent.
Patients not benefited	.	.	.	.	.	7 " 14 " "
Patients relieved	.	.	.	.	.	4 " 8 " "
Patients recovered	.	.	.	.	.	2 " 4 " "
Result unknown	.	.	.	.	.	4 " 8 " "

In Macewen's case, which, with the exception of Lauenstein's, is the only one in which the operation can be said to have been followed by recovery, the fracture involved the vertebral laminae only, the injury being, therefore, somewhat analogous to that of Louis's patient (see page 379), and the prognosis being exceptionally favorable.

The following table includes the 50 cases referred to:—

TABLE OF CASES OF RESECTION OF THE SPINAL COLUMN FOR INJURY.

No.	Result.	Operator's name.	Reference.
1	Died	Cline	Chelius's Surgery, ed. by South, vol. i. p. 590.
2	"	Wickham	Lancet, 1827.
3	"	Oldknow	Hutchison, Am. Med. Times, 1861.
4	"	Tyrrell	Malgaigne, Fract. et Luxations, tome i. p. 425.
5	"	Id.	Ibid.
6	"	Barton	Malgaigne (Packard's translation), p. 343.
7	"	Boyer	Heyfelder, Traité des Résections (trad. par Boeckel), p. 244.
8	"	Rogers	Am. Journ. Med. Sciences, O. S., vol. xvi.
9	"	Attenburrow	Chelius and Heyfelder, op. cit.
10	"	Laugier	Malgaigne, op. cit.
11	"	Holscher	Brown-Séguard, Diseases of the Central Nervous System, p. 256.
12	Relieved	A. G. Smith	N. A. Med. and Surg. Journal, vol. viii. p. 94.
13	Died	Mayer	Heyfelder, op. cit.
14	"	South	Notes to Chelius's Surgery, vol. i. p. 591, etc.
15	"	Blackman	Hutchison, loc. cit.
16	Not known	Edwards	Brit. and Foreign Med. Review, 1838.
17	"	Blair	Ballingall, apud Hutchison, loc. cit.
18	"	Goldsmith	Gross, System of Surgery, 2d ed., vol. i.
19	Died	Stephen Smith	Hutchison, loc. cit.
20	"	Hutchison	Ibid.
21	"	Jones	Brown-Séguard, op. cit., p. 255.
22	"	Potter	Hurd, N. Y. Journ. of Med., 1845.
23	"	Id.	Am. Journ. Med. Sciences, N. S., vol. xlv.
24	Not benefited	Id.	Ibid.
25	Died	McDonnell	Ibid., vol. 1.
26	Relieved	Gordon	Med.-Chir. Trans., vol xlix. p. 21.
27	Died	Tillaux	Brit. and For. Med.-Chirurgical Review, 1866.
28	"	Willett	Med. Times and Gazette, Feb. 2, 1867, and St. Barthol. Hosp. Rep., vol. ii. p. 242.
29	Not known	H. J. Tyrrell	Dub. Quart. Journ. Med. Sci., Aug. 1866.
30	Died	Maunder	Med. Times and Gazette, Feb. 23, 1867.
31	Not benefited	Eve	Am. Journ. Med. Sci., N. S., vol. lvi.
32	Died	Cheever	Boston City Hosp. Reports, p. 577, 1870.
33	"	Id.	Ibid., p. 580.
34	"	.....	St. Barth. Hosp. Reports, vol. vi.
35	"	Nunneley	Med. Times and Gaz., Aug. 7, 1869.
36	"	Id.	Ibid.
37	"	Id.	Ibid.
38	Relieved	Id.	Ibid.
39	Died	Willard	Am. Journ. Med. Sci., N. S., vol. lxiii.
40	Relieved	Stemen	Fort Wayne Journ. of the Med. Sciences, April, 1883.
41	Not benefited	Id.	Ibid.
42	Died	Id.	Ibid., Oct. 1883.
43	Not benefited	Lucke	Revue des Sciences Médicales, Avril, 1880.
44	"	Id.	London Medical Record, March 15, 1887.
45	Died	Pinkerton	Medical News, Jan. 3, 1885.
46	"	Halsted	Ibid.
47	Recovered	Macewen	Glasgow Med. Journal, March, 1886.
48	"	Lauenstein	London Medical Record, March 15, 1887.
49	Not benefited	Albert	Ibid.
50	"	R. T. Morris	Annals of Surgery, June, 1886.]

MALFORMATIONS AND DISEASES OF THE SPINE.

BY

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SPINA BIFIDA.

THE term "spina bifida" is applied essentially to a hernia of the membranes of the cord through a congenital fissure in some portion of the bones forming the spinal column.

PATHOLOGICAL ANATOMY.—Speaking generally, the congenital deficiency that leads to spina bifida is in the posterior segments of the column, and is at the expense of the laminae and spinous processes. Through the bony gap the spinal membranes protrude, distended by an abnormal amount of cerebro-spinal fluid. Often the cord itself, or some part of it, takes a share in the protrusion. The spina bifida, therefore, appears as a tumor of variable size, situated in the middle line, covered with normal or more or less modified integuments, and presenting the essential features of a simple cyst.

CAUSES.—As to the *causes* of spina bifida nothing definite can be said, and the etiology of the affection must for the present be hidden under the general term, "arrest of development." A vast number of theories have been propounded upon the subject, supported for the most part by a minimum of facts; and it must be confessed, that in spite of long argument and a multitude of opinions, little real addition has been made to our knowledge of the causes of this and like deformities. Perhaps the most essential question that requires to be answered is this: Which is the primary defect, the arrest of development in the bones, or the dropsy of the membranes? Does the deficiency in the bony canal encourage a protrusion of the membranes, or has the protrusion prevented the proper formation of the osseous canal? Those who are interested in this discussion will find the matter fully argued out by Follin and Duplay, in their *Traité de Pathologie Externe*.

SITE.—The common situation for spina bifida is in the lumbo-sacral region. Indeed, it may be said that the deformity is rare elsewhere. Next in frequency to the lumbo-sacral region comes the upper cervical region, and then the rest of the cervical spine, while the least frequent spot for a spina bifida is the mid-dorsal region.

NUMBER.—The spina bifida is usually single. In rare cases, however, there may be two examples of the deformity in the same person. Thus there may be a spina bifida in the lumbo-sacral region, and another in the neck. Bryant

figures a case where there was one tumor in the lumbar region and another in the sacral.¹

CONDITION OF THE BONE.—An examination of the vertebra at the site of the spina bifida will show that the spinous process is absent, and that the corresponding laminae are also entirely absent, or more or less defective. The remainder of the bone is usually perfect and well developed. The osseous defect is rarely limited to one vertebra. It usually involves two or three, or more. In some few instances, in monsters, all the vertebrae have been found involved—a condition not compatible with existence. Follin and Duplay² cite some instances where the defect in the bone extended as a cleft through the entire body of the affected vertebra; and Bryant³ has reported the case of a woman, aged 25, who died from accident, and who presented an *anterior* spina bifida. Dr. John Ogle, has recorded a remarkable case of spina bifida opposite the upper lumbar vertebrae, where the body of the second lumbar vertebra was deficient, and was so pushed backward that the first and third vertebrae came almost in contact. The defect was associated with a very marked and abrupt curvature of the spine backwards at the seat of the spina bifida.⁴

THE TUMOR.—The tumor varies greatly in size, and may range from a protrusion the size of a walnut to a mass larger than an infant's head. Broca exhibited a case in an adult man, where the circumference of the tumor was 45 centimetres (17.5 inches). The usual size of the tumor at birth is from that of a bantam's egg to that of a small orange. According to Follin and Duplay, there may be no tumor at all, but merely a cordiform or oval patch on the skin, associated with no elevation of any kind. It is asserted that this condition may occur with division of many vertebrae. The tumor is usually round, or oval, with its greatest axis longitudinal, and is of regular outline. The wall of the sac is thin and ultimately adherent to the skin or its representative. In cases that have existed for some years, the sac wall may become greatly thickened, and may present some calcareous change. In certain large tumors the outline of the mass may be bossy and irregular, probably from unequal resistance of the envelopes. The tumor may be sessile, but it is usually pedunculated. The size of the pedicle depends upon the size of the hole in the vertebral canal. In process of time the pedicle tends to become lengthened, a condition that depends much upon the weight of the tumor, the size of the opening into the spinal canal, and the maintenance of the vertical position.⁵ The skin covering the spina bifida is rarely normal. It is usually thinned and deficient, often shining and purple, and not unfrequently inflamed. In other cases the skin may be hard and coriaceous; it may be hairy, or in a condition of ichthyosis. Sometimes it is found to be hypertrophied, although more commonly it is deficient, and may be entirely absent. In the latter case, the spinal dura mater is exposed as a bluish-red and vascular membrane. The defective skin, moreover, may be represented by a scanty fibrous material, not unlike cicatricial tissue, or the integuments may be hypertrophied at the periphery of the tumor and atrophied at its centre. The deficiency in the integuments may depend upon congenital defect in those parts, or may be due to a wasting of the coverings of the tumor, consequent upon increasing pressure from within. In many cases the coverings of the spina bifida are curiously inflamed and appear very vascular and rugose; or they may be sloughing, or

¹ Manual for the Practice of Surgery, 2d ed., vol. i. page 256.

² Traité de Path. Externe, tome iii. p. 709.

³ Path. Soc. Trans., vol. ii. page 299. 1860.

⁴ In a case recorded in the Boston Med. and Surg. Journ., July, 1862, page 436, the pedicle is said to have been "about a foot in length."

⁵ Medical Gazette, 1838.

the seat of more or less considerable ulceration. A nævoid condition of the skin is by no means uncommon, either over or about a spina bifida. When the skin is dissected off, the true sac of the tumor is met with. This is formed from the membranes of the cord matted together. No layers, however, can usually be made out, nor can the integuments be distinctly separated from the protruded membranes. In cases where the skin is quite normal, however, a layer of loose connective tissue often exists between the membranes and the most external coverings of the protrusion. Mr. Thomas Smith has recorded a remarkable case where the tumor contained two distinct sacs. The tumor, in this instance, was large and pendulous, and opened from the lower lumbar region. It was translucent, but presented no impulse on crying. The child was 14 months old, and, apart from the tumor, in perfect health. The mass was tapped, and 8 ounces of clear fluid drawn off. The patient died in ten days from spinal meningitis. At the autopsy, a second and smaller cyst was found at the upper part of the mass, that had not been punctured. Between the two cysts was a strong membrane, and in this position also ran the cauda equina. The bony opening was at the last lumbar vertebra. The larger or lower cyst communicated with the spinal canal and contained a few nerves. The smaller cyst led by a funnel-like process to the centre of the cauda equina and subarachnoid space.¹ Sir James Paget has also recorded a case of two sacs in a spina bifida, one inclosing the meninges and cord, and the other occupied by fibrous and fatty tissue.

CONTENTS OF THE TUMOR.—The sac of a spina bifida contains more or less fluid, which is identical in composition with the cerebro-spinal fluid. There is no doubt, moreover, that this fluid and the fluid in the sac of the tumor are one. The fluid may be found either between the cord and its membranes (hydrorachis externa or hydro-meningocele), or may be found in the central canal of the cord (hydrorachis interna or hydro-myelocele). In the latter case, the cord is usually found spread out so as to form a thin covering over the wall of the sac, and its condition may be compared to that of the brain in severe hydrocephalus. Follin and Duplay believe that in at least three-fourths of all cases the fluid is formed within the centre of the cord. In all cases where the fluid has apparently accumulated in the central canal, an extensive spreading out of the substance of the cord is not necessary. In many instances the cavity of the sac has been found to communicate by a funnel-shaped opening with the central canal of the cord, while yet the thinning or expansion of the cord was very slight.² In all these cases the communication has been at the lower part of the medulla spinalis; and while it is probable that in these instances the fluid originally accumulated in the central canal, it is equally probable that the collection communicated at an early period with the subarachnoid space. In some cases cerebro-spinal fluid may form the sole contents of the sac in spina bifida; but such cases are exceptional. As a rule, the spinal cord, or some part of it, and a certain number of the spinal nerves, are included in the protrusion. Follin and Duplay state that some nerve-tissue is found in the sac in five-sixths of all cases. Out of twenty cases of spina bifida, reported by Sir Prescott Hewett, in one instance only was the sac free from nerve-structures.³ The relation of the cord or of the spinal nerves to the sac varies greatly. In some cases the cord may bend into the sac, and, having possibly contracted some adhesions there, may re-enter the spinal canal; or the cauda equina, with more or less of the lower end of the cord, may

¹ Trans. Path. Soc., vol. xxi. page 1. 1869.

² See drawing of a dissection in Bryant's Surgery, vol. i. p. 255.

³ London Medical Gazette, vol. xxxiv. 1844.

pass through the bony opening, and, entering the sac, become adherent to its inner wall. In such cases the termination of the medulla spinalis is often indicated by the point of its adhesion to the protruded sac; and this adhesion is, in some cases, marked by a depression on the outer surface of the cyst.

Sometimes the cord-structure is found spread out as a thin coating of nerve-tissue over the inner surface of the cyst, a condition depending upon great accumulation of fluid in the central canal of the cord. In other instances the cord may be fairly sound, and the cauda equina may be spread out as a lining to the cyst wall; or the extremity of the cord may be, as it were, dissected up into bundles, and thus be made to represent an unduly large and coarse cauda equina. Sometimes only a few nerves are to be found in the sac, scattered about its posterior wall, or hanging loosely in the fluid with which it is filled. Speaking generally, the nerve-structures, when they occupy the sac, tend to observe, for the most part, the middle line and the posterior aspect of the tumor; and it may be said that the larger the opening in the bones, the more probable is it that a large amount of nerve-tissue will be found in the cyst, and *vice versa*. In spina bifida not only may the cord be defective, or its parts disturbed in the manner just indicated, but the great nerves concerned in the deformity may also show certain deficiencies. Thus, Dr. Fisher¹ found in two cases of spina bifida that he examined, a fusion of two or more of the sacral ganglia, and observed that the corresponding nerves passed through the spinal membranes in one bundle. South,² commenting upon this observation, says that he has himself verified it in a case which he examined after death following puncture. Some few, rare instances have been recorded where the sac contained, in addition to cerebro-spinal fluid and some cord or nerve-structures, a certain amount of fibrous and fatty tissue.³ [See page 560.]

SYMPTOMS AND DIAGNOSIS.—The tumor in spina bifida is congenital, is always in the middle line, and always closely and distinctly connected to the subjacent bone. In many cases the defect in the bone can be felt when the tumor is drawn away from its attachments. The tumor is round or oval, and usually of regular outline. It feels tense and elastic, and, as a rule, presents very distinct fluctuation. If the coverings of the cyst be thin, the mass may be as translucent as a hydrocele. The integument over the tumor may be normal, or may present any of the conditions that have already been described. The mass is generally constricted at its base, if not distinctly pedunculated. Careful attention must be paid to those symptoms that mark the connection of the cyst with the interior of the spinal canal. Chief among these symptoms are the following: The size and tenseness of the mass can be diminished by pressure. Such pressure will often cause evident pain or convulsions, or limited muscular spasms, and if continued may induce a state of coma in many instances. When hydrocephalus exists at the same time, pressure upon the tumor causes increased tension at the anterior fontanelle; and, in like manner, pressure at the anterior fontanelle produces some increase in the sac of the spina bifida. These mutual pressure-effects cannot be seen unless the head is hydrocephalic. If the pelvis be raised above the head, the tumor becomes softer, while its tension is increased during the act of crying. These evidences of a communication between the sac and the spinal canal are more marked in large tumors than in small, and in those without a pedicle than in those possessed of one. It will be obvious that the smaller the orifice between the sac and the canal, the less marked will be the evidences of the communi-

¹ London and Edinburgh Philosop. Mag., vol. x. p. 316. 1837.

² Chelius's System of Surgery, vol. ii. p. 466. 1847.

³ Holmes's System of Surgery, 2d ed., vol v. p. 804.

cation. The complication of hydrocephalus tends to render the symptoms of communication much more distinct.

Spina bifida is very commonly associated with some gross nerve disturbance, due to injury or defect in the cord or great nerves at the seat of the deformity. Thus talipes is very frequent, and especially talipes equino-varus. There may be a loss of power in the lower limbs that may present any grade from mere muscular weakness to absolute paraplegia. With this paraplegia there may be paralysis of the sphincters, although this latter symptom may exist independently of paraplegia. With the loss of movement in the lower limbs, more or less loss of sensation may be associated, and, as a rule, both movement and sensation are impaired together, the impairment of motion, however, being the more marked of the two. According to Follin and Duplay, there may be loss of sensation only in the lower limbs, but such a condition must be quite uncommon. In some equally rare instances the affected limbs are hyperæsthetic. Launay¹ has recorded a case where there was loss of both motion and sensation in the right lower limb, with loss of movement only in the left. Hydrocephalus is commonly associated with spina bifida, and in the course of any case convulsions are not infrequent. It is difficult to say positively, in all cases, whether the cord is or is not in the sac of the spina bifida. It may be safe to suspect its presence in the tumor, unless there are indications to the contrary. The larger the opening into the spinal canal, the more probably will the cord be found in the sac, whereas such a complication is but little to be suspected when the bony opening is small and the pedicle long and narrow. In those cases that are associated with hydrocephalus, the cord, or at least some part of it or of its main nerves, are very usually to be found in the cyst of the spina bifida. The existence of talipes, or of paralysis, the occurrence of convulsions, the readiness with which nerve symptoms are produced by pressure, are all in favor of cord tissue being associated with the protrusion.

Follin and Duplay have pointed out that when the termination of the cord is adherent to the posterior wall of the sac, the site of the adhesion is often indicated by a depression on the surface of the tumor in the middle line. In many cases also where the cord is adherent to the sac, its position is indicated by undue thickness of the cyst wall at one part, and possibly also by some loss of translucency. A vascular and reddened condition of the skin is said by some to indicate adhesion to the parts beneath.

It is probable that complete paraplegia will in all cases depend upon hydiorachis interna.

The *diagnosis* of spina bifida is rarely a matter of difficulty. The disease has been confused with certain tumors that have occupied the middle line, and have been congenital; but in such growths the laminae and spinous processes of the vertebræ have been felt intact beneath the tumor, and it has been possible to demonstrate the absence of any adhesion between the tumor and the bone. In such cases, moreover, there has been an absence of those symptoms that indicate a communication between the tumor and the spinal canal. Sometimes the sac of a spina bifida becomes cut off from all communication with the vertebral canal, and then the diagnosis between such a cyst and a congenital cystic growth in the middle line is practically impossible. Not only is the diagnosis often impossible in such cases, but it is also quite unimportant, inasmuch as the treatment in the two affections is identical. The points of difference between spina bifida and certain congenital growths in the regions common to spina bifida, will be dealt with hereafter.

¹ Bull. de la Soc. Anat., 1859, page 342.

PROGRESS AND PROGNOSIS.—The common tendency of spina bifida is towards rupture of the sac. The tumor usually increases steadily, and in time reaches such dimensions that the skin or coverings of the protrusion give way. The contained cerebro-spinal fluid is then discharged, and death very commonly follows from convulsions, or less frequently from inflammation of the spinal membranes. The rate at which the tumor increases varies greatly, and can hardly be definitely laid down. In several instances the sac has ruptured *in utero*, and the infant has either been born dead, or has survived its birth but a few hours or days. Often the tumor has given way during birth, and its contents have been discharged with a more or less rapidly fatal result. Sometimes the rupture is represented by but a small hole in the skin; this heals and the sac refills. In such a case, a second rupture of the sac may end in death, or the opening caused by the rupture may remain patent and a fistula be established that is, however, soon attended by a fatal termination. In certain instances the contained fluid may escape through the greatly thinned skin without any opening being apparent. In the minority of all cases spontaneous cure takes place. Such a cure is most likely to occur in cases where the tumor is small, possessed of a small and narrow pedicle, and occupied by no part of the cord, or of the great spinal nerves. In such a tumor the abnormal opening may gradually close, the fluid in the sac may be absorbed, and the mass may shrink and almost disappear; or this end may be brought about by some adhesive inflammation at the root of the tumor, whereby the obnoxious orifice is closed and a good result follows. Many cases are recorded where a complete cure has followed upon the spontaneous rupture of the sac, and Holmes cites a case where a like fortunate result followed upon the suppuration and bursting of the cyst in a child aged six months.¹

The tumor may increase in size for years, and then suddenly cease to grow, and begin to exhibit a retrograde movement that in time will end in a cure of the deformity.²

In the Transactions of the Pathological Society³ is an account of a case where a spina bifida, the size of the patient's head at birth, was rapidly undergoing spontaneous cure at the age of twelve months. Patients with spina bifida have reached the ages of 28, 37, 43, and 50 years.⁴

TREATMENT.—The treatment of spina bifida may be classed as *palliative* and *curative*.

Palliative treatment consists simply in protecting the part from friction or injurious pressure, and in retaining in as healthy a condition as possible the coverings of the protruded mass. These ends can be best effected by enveloping the mass in a pad of cotton-wool smeared with vaseline, and secured to the part by means of a circular bandage so applied as to exercise some pressure upon the tumor. By these simple means the growth of the tumor has been arrested or greatly modified, the amount of inflammation in the skin has been lessened, and any progressive thinning of the cyst-wall has been considerably retarded. I believe that this very rudimentary plan of treatment is better than that of keeping the part constantly painted with collodion. The pressure exercised by the contracting collodion is slight and superficial, the application itself often increases rather than diminishes the inflammation of the skin when it exists, and when that inflammation

¹ Surgical Treatment of Children's Diseases, page 82.

² See a case in Med.-Chir. Trans., vol. xl, page 19, where the tumor continued to grow steadily for three years and then began to decrease.

³ Vol. xvi, page 13.

⁴ Case by Behrend, Journ. für Kinderkrankheiten, Bd. xxxi. S. 350.

has proceeded to actual ulceration, I presume that the use of collodion would be very generally considered as inapplicable, even if possible.

Before any more active measures are proposed, it is well to consider the relations and surroundings of the tumor. The true spina bifida communicates with the cavity of the spinal membranes, and usually contains either the cord or some part of it, or a certain number of the lowest spinal nerves. Any operation, therefore, upon such a tumor must involve the spinal membranes, and probably the medulla spinalis itself, and it is unnecessary to point out that an operation with such incidents must be among the most serious that can be entertained in the practice of surgery.

In the face of these serious features in any operative proceedings for the relief of spina bifida, it has been pointed out that the cases most suitable for operation are those where the bony defect is trifling, the tumor well pedunculated, and the cord and its nerves free from any participation in the protrusion. This is obvious; but these very cases that are considered the best suited for operation, are the very cases that are the most prone to undergo spontaneous cure. I would venture to urge that the possibility of spontaneous cure in spina bifida has been a little too lightly estimated, and that, while perhaps harm may be done by temporizing with a case, that harm is not so very unevenly balanced by the mischief that has followed upon hasty, premature, and ill-conceived operations. There are not a few cases on record that, like the following example, would urge a greater tolerance of the possibility of spontaneous cure. A man, aged twenty, had a spina bifida that had of course existed from birth. It was of great size, but, apart from the inconvenience attending its large bulk, it gave him no trouble. For twenty years, then, it had caused no serious or even very troublesome symptoms. At the age of twenty, the tumor was tapped. With what result? Within six days of the second tapping the man was dead.¹

Looking over the records of the treatment of this deformity, one is struck with the immense number of cases of spina bifida that have been subjected to operation within a few days—nay some even within a few hours—of the birth of the victim. In such cases, the possibility of spontaneous cure can hardly have been considered, and it remains with those who have undertaken such operations to show upon what grounds these apparently premature and hasty measures have been adopted. I would then urge a little patience as the first factor in the treatment of spina bifida. Let the first measures be palliative, and let operative measures be considered when some definite indications for further treatment arise. These indications may be afforded by the rapid growth of the tumor, by the probability of its speedy rupture, by the onset of convulsions or other nerve disturbance, or by the increase in a paralysis that has perhaps always existed to some extent.

The principal *curative* measures (so called) may be considered under the head of (1) Puncture, (2) Injection, (3) Ligature, and (4) Excision.

(1) *Puncture*.—There are many cases where the only symptom that requires to be immediately dealt with is the rapid increase in the size of the tumor, or in the degree of its tenseness. I think that such cases can—for a while at least—be very well treated by puncture. I might best illustrate the matter by reference to two cases at present under my care at the London Hospital. One patient is aged nine, and the other six months. Both tumors are in the lumbo-sacral region; they are both large, and have but thin coverings. In each case the skin is inflamed about the summit of the cyst, and has been many times ulcerated. There is reason to believe that the cord, or some part of it, has a share in the protrusion in each instance. For some weeks after

¹ TRANS. PATH. SOC., vol. viii. page 10.

birth, the tumors were simply kept covered up with cotton-wool smeared with vaseline, and some slight pressure was maintained over the part by means of a bandage. The history and progress of the two cases are so similar that they may be treated as one. In time the tumor increased in size and in tenseness, the child became restless and convulsed, and the undue tension in the cyst appeared to be the cause of these fresh symptoms. The tumor was then tapped as far from the middle line as possible, with the finest trocar, and enough fluid (about $1\frac{1}{2}$ drachms) let out to relieve the tension. The wool was then reapplied, and the pressure of the bandage again maintained. Immediate relief followed. In the child aged nine months I have thus punctured the cyst, I dare say, a dozen times, but the necessity for such punctures has become less and less frequent, and the operation has not been performed for the last three months. The tumor is now apparently stationary. The child is still—as it always has been—partially paralyzed in its lower limbs; but it has had no convulsions for months, and it is in fair health. As far as I can judge, there is in this case a large defect in the bone, and the cord is in the sac. But what operation can be done—as far as our present knowledge goes—to close this defect and restore the cord to its proper place?

To ligature or to excise the mass would probably be to ligature or excise the cord or some part of it, and I can hardly believe that iodine injection could loosen any adhesions that may exist between the cord and the sac, restore the cord to its proper canal, and close the defect in the bone. In the child aged six months, the tumor is increasing, but is kept within bounds by frequent tapping—sometimes once a week, or once a fortnight—and the child appears, apart from the tumor, to be well. I think, then, that in certain cases, the treatment by puncture and gentle pressure may be advised, not, perhaps, so much as a means of cure, but as a measure for prolonging life and rendering the existence of the patient less distressing than it might be. I can, however, well believe that it may in some cases lead to a cure, although a paraplegia or other gross nerve-lesion may persist. It would appear that the smallest possible puncture is the best, and that it should always be made, when available, through healthy skin. The less fluid drawn off at each operation the better. It is merely required to lessen the tension. The subsequent pressure should be slight and evenly applied. I believe that this treatment originated with Sir Astley Cooper. That surgeon at least reported two cases where he had adopted this measure and with very good success.¹ The practice of simple puncture, with evacuation of the entire amount of the contained fluid, is strongly to be condemned. It would appear to have led in most cases to severe and fatal convulsions, and in certain instances to almost sudden death. It must be remembered that puncture under any circumstances may be followed by inflammation of the sac.

(2) *Injection.*—This mode of treatment has so far been the most successful that has been made use of in this deformity. Many fluids have been used for injection, but the only one that has proved of any practical use is iodine. The tumors best suited for this method of treatment are those that present the condition most favorable for spontaneous cure, and it is in such cases that successful results have, for the most part, been obtained. When there is a free communication between the sac and the spinal canal, and when the cord or the large nerves enter into the protrusion, the success of the operation, and indeed its very advisability, are matters of considerable doubt. There are many who maintain that the treatment by injection is not justifiable when the hole leading from the sac to the cavity of the spinal membranes is

¹ Med. Chir. Trans., vol. ii. page 324. Bryant, in his "Surgery," 2d ed., vol. i. page 257, gives an account and a drawing of a case cured by repeated puncture with a needle.

large and free, or when the contents of the cyst are other than simple fluid. If then only selected cases are considered suitable for this measure, its success must be estimated at a proper value. I am aware of no case of cure from iodine injection where it was distinctly proved that a free communication existed between the interior of the sac and the spinal canal, that could not be even temporarily cut off, and where at the same time the cyst contained the cord or some considerable portion of it. The methods of using this iodine treatment vary.

Brainard, of Chicago, adopted the following plan: Six ounces of the fluid in the cyst were drawn off, and half an ounce of an iodine solution was then injected. This, after a few seconds, was allowed to flow out, the sac was then washed out with water, and the operation was completed by the injection of two ounces of the original cerebro-spinal fluid that had been kept in the meanwhile at the temperature of the body. After the operation, pressure was applied. Brainard's solution consisted of iodine, 5 grs., potassium iodide, 15 grs., and water, one fluidounce.¹ Velpeau withdrew all the fluid in the cyst, and then injected a solution of tincture of iodine and water, after the manner adopted in the treatment of hydrocele. Morton's method appears to have the advantage over both these plans, and is probably the most successful method of using iodine that has been proposed. Morton uses a solution of ten grains of iodine and thirty grains of iodide of potassium in one ounce of glycerine. The operation is not advised until the child has passed over the "accidents of birth," unless a speedy bursting of the tumor is threatening. A little of the cerebro-spinal fluid is drawn off, and then from half a drachm to one drachm or more of the "iodo-glycerine solution" is injected. This is allowed to remain in the cyst. The puncture is then painted with collodion. The operation may need to be repeated several times at intervals of a week or ten days, or longer. Some little inflammation commonly follows each injection, but it usually remains limited.² If a good result follows, the mass shrinks, and soon ceases to give trouble. In a recent communication, Dr. Morton³ states that, as far as he knows, 29 cases have now been treated by this method. Out of this number failure has occurred in six instances only, and from this Dr. Morton argues that the iodo-glycerine solution treatment has brought about a saving of life to the extent of 79.31 per cent. Before, however, this very pleasing conclusion is accepted, it would be desirable to have more full details as to the exact condition of the various cases operated upon, and especially as to the anatomical relations of the parts concerned in the tumor.

The failures from the injection treatment have depended upon inflammation involving the spinal membranes and cord, upon convulsions independent of such inflammation, or upon suppuration and premature bursting of the sac.

(3) *Ligature* and (4) *Excision*.—These operations can only be undertaken in those comparatively infrequent cases where the sac is quite free from either the cord or any of the spinal nerves. The smaller the tumor, the smaller the bony hole, and the narrower the pedicle, the greater is the chance of success. The real danger is, that the inflammation incident upon healing and upon the closure of the aperture in the bony canal, may extend inwards and extensively involve the spinal membranes. It would be of no avail to detail the many modes in which these operations have been carried out. The ligature has been applied gradually, and it has been applied suddenly. The mass has been allowed to fall off, and it has been taken off at once with the *écraseur*. Ex-

¹ Am. Journ. Med. Sciences, vol. xlii. page 65. 1861.

² See Lancet, vol. ii. 1876, pages 776 and 881.

³ Glasgow Medical Journal, 1881, page 401.

cision has been preceded by ligature; excision has been performed with or without the preliminary use of a clamp. It has been executed in a great variety of ways: by excising the whole, or by excising a part; by invaginating the collapsed membranes, or by cutting them off close to the bone. It has been followed by the use of the cautery, and by the application of divers kinds of suture. It has, indeed, been practised with all the ingenuity that is a feature in the history of so many surgical procedures.

The *modus operandi* is of little moment. If the sac contain cord-elements, the result will prove fatal; if not, success may possibly follow. The operations are, as far as surgical science at present goes, restricted to cases that present in a marked degree the elements necessary for spontaneous cure, and to cases where that cure has so far advanced that the opening in the bones has become closed, and the tumor gives trouble only by its bulk. If the ligature be used, a superficial cut should be made in the skin at the base of the mass, and a silk ligature should then be applied and drawn sufficiently tight to strangle the mass. In excising the cyst, it should be removed by an oval incision at its base, so planned that after removal the edges of the wound may come together in a clean, straight line. The operation should be done antiseptically, and firm pressure should be maintained until the wound has healed.

An account of the chief operations alluded to under this heading will be found in Mr. Holmes's monograph in his "System of Surgery," 2d ed., vol. v. p. 807. [See page 560.]

FALSE SPINA BIFIDA.

This term has been applied to many different tumors that have, however, for their common characters a congenital origin and a communication with the spinal canal, but not with the spinal membranes. Some of these tumors are solid, some are multilocular cysts, and some are simple cysts. Both pathologically and clinically, they present striking points of difference, and as there appears to be no great advantage in classing these various growths under a common head, I would venture to question the value of this term in its present extended sense. The term false spina bifida should be applied to one tumor only, namely, to a spina bifida whose communication with the spinal membranes, and, perhaps, with the spinal canal itself, has been cut off. Such a tumor is the result of the process of natural cure in cleft spine, and of it many examples have been furnished. The false spina bifida will be found in some region common to this deformity—most probably in the lumbo-sacral region—will be of congenital origin, cystic in structure, and situated accurately in the middle line. It will present no evidence of communication with the spinal membranes; will be, in almost every instance, pedunculated; and will probably have been of some duration. There may possibly be a history to show that such a mass did at one time present all the features of a true spina bifida.

Lacking this fact in the history of the case, the *diagnosis* of false spina bifida is by no means easy. There are certain congenital tumors of a cystic character that may appear in the middle line in regions common to spina bifida, and that may furthermore have an intimate connection with the column. These tumors may closely resemble false spina bifida, but the resemblance will, in most instances, not be of long duration. The cystic tumor is usually multilocular; the false spina bifida a simple cyst. The cystic tumor is apt to grow rapidly, is usually not very distinctly pedunculated, often contains more solid masses in its interior, and is nearly always irregular and bossy in outline. The false spina bifida, on the other hand, tends to diminish rather than to increase in size; its pedunculation is nearly always very dis-

tinged; it contains no separate, solid masses, although it may present a uniform thickening of its sac; and lastly, its outline is nearly always quite smooth and regular.

The diagnosis, however, is of no great moment, as it would suggest no plan of treatment that, while applicable to a false spina bifida, would not be equally applicable to such a cystic tumor as would closely resemble the simple cyst.

Excision is probably the most suitable mode of *treating* these cases, and is the method that has been attended with the greatest success. Injection with iodine has been proposed, but would appear to have no great claim to attention, for the sac of the false spina bifida is often thick, and, even if the sac should become obliterated as a result of the injection, the cyst-wall would still remain with probably a considerable pedicle. If the case should prove to be a multilocular growth, the injection would then be obviously useless. On the whole, therefore, considering possible errors in diagnosis, a cautious excision of the mass is probably the most certain and the safest procedure.

Certain of the following tumors may be—and have been—mistaken for spina bifida.

CONGENITAL SACRO-COCCYGEAL TUMORS.

The sacro-coccygeal region is peculiarly liable to be the seat of certain congenital tumors. Some of these grow from the sacrum alone, and others from both the sacrum and the coccyx, but the majority would appear to have their primary origin from the coccyx alone.

As to the reason why this region is so frequently the seat of congenital growth, nothing definite can be said. It is a problem that still requires to be worked out. It is remarkable that the congenital tumors about the sacrum and coccyx should be much more frequent in the female than in the male. Molk gives 58 cases in which the sex was noted, and of this number 44 were in females, and 14 in males.

These tumors are very varied in their external characters, and are, I think, best classed in the following manner: (1) Attached fœtuses, (2) Congenital tumors with fœtal remains, (3) Congenital cystic tumors of various kinds, (4) Congenital fatty, fibrous or fibro-cellular tumors, and (5) Caudal excrescences.

ATTACHED FŒTUS.¹—The most common example of this condition is afforded by a third lower limb that is attached to the sacral region, and that hangs down between the normal legs of the patient. The condition has been known as "human tripodism." The superfluous limb consists usually of the two legs of another fœtus blended into one. The size and development of this additional member vary. It is usually dwarfed, and often contracted at the knee, and the foot, or feet, commonly much deformed. It may, however, appear well developed, and may even exceed the natural limbs in the degree of its development. In some instances, one of the natural lower extremities of the patient may be wasted and deformed, and in a condition but little better than that of the additional member. This abnormality is associated with certain alterations in the anatomy of the pelvis, and some variation is shown in the manner in which the additional limb is attached to the trunk. In certain less frequent instances, the attached fœtus has been represented by a confused, pendulous mass that exhibits the rudiments of several limbs.

¹ Representations of the principal varieties of attached fœtus are given in Dr. W. Braune's *Die Doppelbildungen und angeboren Geschwülste der Kreuzbeingegend*. Leipzig, 1862.

Such an instance is represented by Braune in his well-known monograph (Plate 3, Figure 7). Usually the superfluous limb is obvious at birth, but it may be concealed for some time within a fibrous sac, and may thus resemble the cystic tumor with fetal contents to be next dealt with. In two or three recorded instances of this condition, the child was born with a sacral tumor that continued for some time to increase, and then gave way, allowing a foot and leg to come out.

The *treatment* of these supernumerary limbs is by amputation. The chief difficulty in any such operation is the connection of the member to the pelvis. But in these cases a disarticulation is not necessary in all instances, nor is it of course desirable to in any way interfere with any pelvic abnormality. It is sufficient to remove the projecting part of the additional member, and this operation would appear from recorded cases to be both fairly simple and more than fairly successful.¹

CONGENITAL TUMORS WITH FŒTAL REMAINS.—These tumors present themselves under a great variety of aspects. Usually they appear as roundish or irregular tumors, pendulous from the sacro-coccygeal region, and covered with a thin and often purplish skin. Beneath the skin is a sac, lined with a smooth membrane, and within this sac is a certain amount of fluid, and foetal remains of the most variable nature and aspect. These foetal remains usually present themselves in the form of an irregular, solid mass, bony, pendulous, and imperfectly pedunculated. This mass is composed of fatty and fibrous tissue, and presents usually a number of multilocular cysts, variously disposed. Some part of the mass may present fingers or toes, or rudimentary limbs. In other cases the tumor may contain portions of bone, most usually portions of the vertebræ, or fragments of cartilage, with here and there some ill-formed and indefinitely arranged muscular tissue. In other instances the mass has presented a knuckle of gut, that has sometimes contained a material like meconium. Some few of these masses would appear to have been dermoid, and have contained hair, teeth, and fragments of bone.

These tumors may occupy the subcutaneous tissue, but usually they are more deeply seated, and they are, as a rule, closely adherent to the bone. They may communicate with the spinal canal, but such communication is quite rare. Sometimes they extend deeply into the pelvis, and a large congenital tumor may in addition be found in that region; their size varies greatly; they are apt to be pendulous, but are seldom well pedunculated. Stanley has reported a case where the tumor reached almost to the feet.² Braune has detailed the case of a girl, who presented a congenital mass of this nature that was pendulous and attached to the buttock by a stout pedicle. The tumor contained the rudiments of limbs. It increased in size, and at the age of 16 was 26 inches long, and weighed 20 lbs. It was then successfully amputated. These tumors usually grow after birth, and, as a rule, their growth is rapid. The skin covering the mass may give way, and the foetal remains contained within may protrude. This may or may not be preceded by more or less inflammation or sloughing of the excrescence. In one or two instances these tumors have been associated with a spina bifida in the sacral region.

Sometimes the foetal remains are not contained within a sac, but are freely exposed. Such a condition rather approaches that alluded to under the term "attached foetus." Such tumors are very irregular in outline, and still more irregular in composition. They may present, in addition to much fatty and

¹ For an account of the cases operated upon, see Braune's work, and also an excellent article by Mr. Holmes, in his *System of Surgery*, 2d ed., vol. v. page 801.

² *Med.-Chir. Trans.*, vol. xxiv. page 235.

cystic tissue, the rudiments of limbs, portions of bone or cartilage, or representatives of the head and of the intestinal tract. A complex variety of such a tumor I have described in Vol. XXXIII. of the Pathological Society's Transactions.

Treatment.—These tumors have been subjected to many operations for the purpose of effecting their removal, but the most successful measure of this kind that has been proposed is excision. If the mass is considered suitable for removal, there is no better plan of accomplishing this than by the knife. The ligature is strongly to be condemned, and the galvanic cautery has no advantages over the knife, while it entails certain grave additional risks. These tumors are not extremely vascular, and such hemorrhage as has occurred during their removal appears to have always been readily checked. Excision of the mass is only to be advised in those cases where the tumor can be entirely removed without great difficulty, and without damage to neighboring important structures. These tumors are usually well defined at their origin, and show less inclination to invade the pelvis than do those which are treated of in the next section. They sometimes communicate with the spinal canal, and, unfortunately, the existence of that communication cannot always be foretold. In cases, therefore, where the mass is well limited as to its origin, where the pelvis is quite free, and where no communication with the spinal canal is expected, the tumor may be excised, provided that the general condition of the patient afford no counter-indications. Molk notes eight examples of removal of these masses, and of this number seven were successful. The statistics given by Holmes show a like good result. If the tumor be left, it will probably in time bring about a fatal result, the patient dying of marasmus, or of the effects of inflammation, suppuration, or sloughing of the mass. A great number of the subjects of these growths are born dead.

CONGENITAL CYSTIC TUMORS.—These constitute the greater number of the congenital tumors that are met with in this region. They present considerable differences, both in their external appearance and in their internal structure. Some few are single cysts, but the bulk are multilocular growths. The *single cysts* comprise spina bifida of the sacral region, and false spina bifida of the same locality.

It is well known that spina bifida in the sacral region alone is rare, and it has, I think, been tolerably well shown that coccygeal spina bifida does not, and cannot, exist. Into the features of spina bifida of the sacral region it is unnecessary to enter, after what has been already said. With regard to false spina bifida, it is probable that it constitutes the sole form of simple cyst in this region, or, perhaps, to be more precise, the sole form of deep-seated simple cyst. In a number of instances, these simple cysts in the sacro-coccygeal region have been shown to have been at one time directly connected with the spinal membranes, and the accounts given of other cases of simple cyst in this part do not appear to oppose the idea that they also are to be regarded as examples of false spina bifida.

The *multilocular cystic growths* form the most important series of tumors encountered in this region. They arise usually from the anterior surface of the sacrum or coccyx, and less frequently from the posterior surface of one or both of those bones. The size of the tumor varies greatly. It may be no larger than a walnut, or it may exceed the dimensions of the child's head. Some, indeed, have been enormous; and the bulk of these tumors tends to rapidly attain considerable dimensions. In outline they are roundish or oval, generally very irregular and bossy, and forming pendulous masses. There is usually a distinct pedicle in all those growths that have no extensive ramifications in the pelvis. The skin covering them is thin and transparent, and

presents large and distinct superficial veins. The mass is usually of very unequal density, some parts being elastic or fluctuating, while others are firmer and more solid. The growth may communicate with the spinal canal, but such communication is quite exceptional.

When the mass grows from the front of the sacrum or coccyx, the latter bone is usually pushed backwards as the tumor develops, and may be so far turned back as to project beneath the skin. In other cases the coccyx is quite buried in the tumor, or it may be rudimentary, or even entirely absent. If the mass is of any great size, the anus and genitals are pushed forwards, and the rectum is sometimes found enveloped by the growth. The tumor may still further invade the pelvis, and its development within that cavity may be such that the pelvis may be filled, and the mass may then be found to occupy some part of the abdomen.

In structure, these tumors are, for the most part, composed of a number of cysts, varying in size from that of a pea to that of a horse-chestnut, and communicating more or less freely the one with the other. These cysts contain a fluid that resembles that of hydrocele, or they may be occupied by a gelatinous material very much like boiled sago-grains. These cysts are held together by a varying amount of firm, young, fibrous tissue. Some of the tumors may be composed solely of this cystic structure,¹ while others, and these are the majority, contain more or less solid tissue in addition.²

This solid tissue may be fatty or fibrous, or it may contain some particles of cartilage, or even of bone. Sometimes it preponderates in amount over the cysts, and the mass is rather a mass of fatty or fibrous tissue associated with some multilocular cysts than a tumor that can be fairly called cystic.

As to the real nature of these tumors, little that is definite can at present be said.

On microscopical examination, the cysts are found to be lined with cubical or columnar epithelium, and to be supported by a very cellular connective tissue.³ This connective tissue, which would appear to be no other than embryonic connective tissue, has been considered by some to be sarcomatous in its nature, and upon these grounds a number of these tumors have been classed as sarcomata or cystic sarcomata.

Others, paying greater heed to the epithelial growth about the cyst-walls, have maintained that these tumors are to be regarded as cylindrical-celled epitheliomata, and are therefore to be classed with the cancers. I do not think, however, that either of these accounts of the nature of these growths has been by any means well established, and it still remains more than probable that these remarkable tumors must be regarded as the results of some abnormal and unknown phase in the tissue-formation of the fœtus. Some pathologists have endeavored to maintain that these growths are due to a degenerative process involving Luschka's gland. It is true that a vast number of these tumors take origin from the front of the sacrum and coccyx, and it is also true that no trace of Luschka's gland is to be found in these instances; but here the main facts end. It has never been distinctly proved that the tumor has actually had origin from this little body, a resemblance in structure between the two has never been fully established, and the loss of the gland by its becoming embedded in the growing tumor is not hard to understand. In spite, therefore, of the eminent names associated with this theory, it must still be regarded as not proven.⁴

¹ See case by Mr. Shattock, *Path. Soc. Trans.*, vol. xxxii. page 197. 1882.

² Hutchinson, *Illustrations of Clinical Surgery*, vol. ii. page 36. 1879.

³ For some excellent drawings, see *Path. Soc. Trans.*, vol. xxxii. page 197.

⁴ See Mr. Hutchinson's work above referred to; also art. *Sacro-coccygienne*, by M. J. Chauvel, *Diet. Encyclop. des Sc. Méd.*, 1878.

Such of these tumors as contain fœtal remains, serve to connect this series of tumors with those dealt with in the previous paragraph.

Progress, etc.—In many instances the children presenting these growths are born dead. A large number die within a day or so of birth. In those who survive, the tumor generally grows rapidly, and often very rapidly. The skin may give way in places, and the contents of the subjacent cysts be discharged. After such discharge the aperture may close, or further destructive changes may take place in the part. Bryant records a case where spontaneous cure followed upon the bursting of a cyst in this region.¹ As the growth advances, death may follow from marasmus, or from inflammation and sloughing of the mass, or from extension of the inflammatory process to the cord or pelvic viscera.

Treatment.—In the treatment of these tumors all partial measures are to be condemned. The practice of incising the mass is meaningless, useless, and pernicious. The tapping of a few of the cysts is equally futile. The excision of a part of the tumor only, leaves an inflamed and, perhaps, sloughing stump, from which fresh tumor-tissue will be produced should the child survive. In like manner, to ligature a portion only of the mass, is to do more harm than good, and the same criticism must apply to all attempts to destroy the tumor with caustics or the actual cautery. The mass should be removed entire, or left alone; and the most serious question involved in this matter of treatment is that concerned in the selection of proper cases for operation. The tumors best suited for operation are those in which a good pedicle exists, in which the base of the mass is comparatively narrow, and in which the tumor has neither extended into the pelvis nor is in communication with the spinal canal. Such cases are unfortunately quite the exception. Mr. Holmes has shown, however, that tumors of this nature can be removed even when they involve the pelvis, and extend into that cavity for no little distance.² The question therefore for the surgeon to decide is whether he can remove the entire mass without inflicting such an injury upon the pelvic structures and viscera as no operation would justify. It is impossible to give definite data for the decision of this question. Each case must be judged upon its own merits. It is very often difficult to make out the limits of the entire pelvic growth, although much may be learnt by a rectal examination. Apart from this matter of the pelvis, the possibility of the mass communicating with the spinal canal must be considered, although the evidence that will point to such communication is usually of the scantiest.

Of the various methods available for the removal of these tumors, that of excision is undoubtedly the best, and is the operation that has given the most favorable results.³

CONGENITAL FATTY, FIBROUS, AND FIBROCELLULAR TUMORS.—These growths are not common in this situation, although several examples of each kind have been recorded. They resemble in character the congenital tumors met with elsewhere, that are composed of fatty, fibrous, or fibrocellular tissue, and present the same features with regard to diagnosis, prognosis, and treatment. They may be tolerably superficial, but as a rule have a deep origin. Molk cites five cases of lipomata arising from the front or tip of the coccyx. Sometimes these congenital fatty tumors may be very large, and one case is recorded where such a tumor formed a pendulous mass that reached the calves. In another instance the fatty growth involved the pelvis, and reached such dimensions as to almost fill that cavity.

¹ Manual for the Practice of Surgery, 2d ed., vol. i. page 259.

² British Med. Journ., March 23, 1867.

³ See Holmes's System of Surgery, vol. v. p. 802.

The most interesting examples, however, of lipomata in this region are afforded by those that have communicated with the spinal canal, a complication of great rarity. Mr. Athol Johnson has reported the case of a child aged 10 months, from whose sacral region he excised a fatty tumor that was increasing, and becoming ulcerated on its surface. The mass was found to extend into the spinal canal through a hole in the sacrum large enough to admit a forefinger. Within the canal the mass was found adherent to the membranes, from which it had, indeed, to be dissected off. The child recovered from the operation. The only evidence of cord complication previous to the operation was an occasional convulsive movement in the right leg.¹

Mr. Thomas Smith has recorded a case of congenital lipoma growing from the coccyx, that is said to have closely resembled a spina bifida. The mass was at birth the size of a small egg, but in four months it had reached the size of a foetal head. It was successfully excised by Mr. Smith.²

These tumors, except in those rare instances where they encroach considerably upon the pelvic cavity, should be removed at as early a period as convenient, and no better means is afforded for such removal than by excision.

CAUDAL EXCRESCENCES.—These are of two kinds: (1) bony appendages composed of supplementary coccygeal vertebræ; and (2) certain fibrocellular tumors that assume the form of a tail. Of the former kind Molk gives two examples. Of the latter several instances have been furnished. The tumor in these cases grows from the coccygeal region, and is composed usually of fibrocellular tissue. It contains no bone, and springs from the subcutaneous connective tissue. Being long, narrow, and perhaps pointed, it resembles the tail of some animals. Gosselin³ quotes a case where the appendage was five centimetres (two inches) in length, and was curled forwards along the perineum. Chauvel⁴ also gives a case where the excrescence was of the same length, and of the thickness of a little finger. These tumors are all readily removed with the knife.

In addition to the works of Braune, Holmes, Hutchinson, and others already alluded to, reference may be made to the following monographs dealing with the subject of congenital sacro-coccygeal tumors: Molk, *Des tumeurs congénitales de l'extrémité inférieure du tronc*, Strasburg, 1868, Thèse, 3e série, No. 106. Duplay, *Des tumeurs congénitales de la région sacro-coccygienne*, Arch. Gén. de Méd., 1868, tome xii. Wagstaffe, St. Thomas's Hospital Reports, N. S. vol. iv. (1873), page 213.

ANTERO-POSTERIOR CURVATURES OF THE SPINE.

Under this term are included two precisely opposite conditions, viz., *cyphosis*, or a curving of the spine backwards, and *lordosis*, or a curving of the column forwards.

CYPHOSIS.—In this condition there is abnormal curvature of the column, or of some part of it, directly backwards; and as the term "curving backwards of the spine" is open to some varied interpretation, it is necessary to add that, in all cases, the abnormal curve has its convexity directed posteriorly. Cyphosis may involve the whole of the column, although, as a rule, but a portion of it is implicated. In the majority of instances, indeed, it consists merely in an exaggeration of the posterior curve that normally exists in the dorsal region. Cyphosis may be temporary or permanent.

¹ Path. Soc. Trans., vol. viii. page 16.

³ Clinique Chirurgicale, tome ii. p. 665.

² Ibid., vol. xxi. page 334.

⁴ Art. in Dict. Encyclop. des Sci. Médicales.

Etiology.—In dealing with the etiology of cyphosis, it will be most convenient to classify the causes of the affection according to the period of life at which it has commenced.

The cyphosis of *infants* and of quite young children depends for the most part upon rickets, and consists of a very general and equable curving backwards of the whole column. This rachitic curvature will be treated of hereafter. Quite independent of rickets, however, cyphosis may be developed at this period of life, and under such circumstances will depend upon a normal muscular weakness, if such a term can be allowed. It is well known that the spine at birth is straight, and that the curves that normally mark the adult spine are the result of a subsequent development, and are dependent upon the establishing of a proper equilibrium in the erect posture. For a considerable time after birth the erect position is not required. The normal posture of an infant, indeed, is the posture of lying flat upon its back. Thus it happens that the spinal muscles long remain but imperfectly developed, and it will be seen that the spinal column in infancy may readily be induced to assume almost any species of curvature. In cases of general muscular debility, some cyphosis naturally develops when the erect posture is attempted, and that cyphosis is, indeed, but the outward sign of an inability on the part of the muscles to properly support the spinal column.

A cyphosis from a like cause, will commonly develop in the backs of infants who are continually being nursed in the sitting posture. Such a position is unnatural, and the spinal muscles are usually unable to retain the column erect; the child's spine yields to the pressure of the superincumbent weight, and a more or less extensive posterior curvature is the result. Besides the pernicious habit of nursing infants in the sitting posture, some mothers take particular pleasure in making their children sit upright at as early a period as possible. They appear to consider that an ability to assume this position is an evidence of precocity and rapid development, and is an accomplishment to be fostered as tending to strengthen the back. The result, however, is often a very definite cyphosis, that may become more or less permanent. It must be allowed, however, that the posterior curvature that may develop in the spines of infants and young children shows some tendency to more or less correct itself when the child begins to walk, and begins in consequence to develop those curvatures that are normal to the adult spine.

A cyphosis may develop about *puberty*—especially in weakly girls—either, it would appear, from debility of the spinal muscles in common with the other muscles of the body, or from an undue or disproportionate use of those structures. The causes of cyphosis at this period are, probably, very nearly identical with those that tend to produce a lateral curvature of the spine. The child, perhaps, is engaged for a long time in a sitting posture without proper support to the back. In learning the pianoforte, or in the ordinary routine of school life, this position is often assumed for hours at a time. The muscles, either from inherent weakness or from undue use, become wearied, the back aches, and the child throws the burden of supporting the column upon the ligaments that are not susceptible to a sense of weariness. To effect this the back is arched backwards, and a temporary cyphosis produced; but in time the over-stretched ligaments yield, the elements of the column undergo slight structural changes, and the curve becomes permanent. Cyphosis is the position often assumed by the tired child who is compelled to still retain the upright posture, and it requires merely a frequent repetition of the malposition to render it definite and permanent. As active causes therefore in producing this form of cyphosis, one must recognize any debilitating influences, prolonged sitting or standing without support to the back, too early study, lack of proper muscular exercise, and, as some would urge, the early and continued

use of rigid corsets, that, while mechanically supporting the spine, tend to discourage a proper development of the spinal muscles.

The cyphosis of *adults* may depend upon many causes. It may be induced by an employment that involves prolonged arching of the back, or prolonged stooping, or bending forwards of the head, or it may depend upon chronic rheumatic arthritis of the spine (spondylitis deformans). In most cases, however, the cyphosis of adults is secondary to some previous morbid condition, and is therefore "symptomatic," rather than "essential."

Thus, any disease involving frequent or prolonged dyspnoea may lead to some cyphosis as the result of an attempt to increase the chest capacity by an arching of the dorsal vertebræ. Asthma and emphysema are not infrequently associated with this form of curvature. Chronic painful affections of the abdomen may lead to cyphosis as to a means of relieving pain by avoiding pressure upon tender parts. Thus Follin and Duplay¹ enumerate metritis and chronic peritonitis among the causes of cyphosis.

Muscular rheumatism, either by directly causing contraction of the flexors of the spine, or by rendering the extensors painful and thereby to some extent useless, may lead to this posterior curvature of the column. Jacques Delpech² records the case of a man, aged 25, whose back became so arched and rigid from rheumatism that he could not support himself without crutches. Gymnastic exercise was advised, and in time a complete cure followed.

Cyphosis is very common in the *aged*, and especially among the laboring classes. It depends in many instances upon a general enfeebling of the muscular system, with probably some loss of elasticity in the elastic tissues. Not infrequently it is the result of chronic rheumatic arthritis, and the case figured by Dr. Agnew,³ of an old woman with general cyphosis so severe that when in the sitting posture her chin touched the knees, was probably of this nature. In other instances the arching of the back has been determined by the patient's employment, or by some of the causes just detailed.

Lastly, it must be remembered that cyphosis may be hereditary, and this remark especially applies to a limited cyphosis of the upper dorsal region.

Pathological Anatomy.—Cyphosis may be general or partial. If general, the whole of the spinal column is involved, including even the lumbar region, but this form of the disease is quite rare. The great majority of the cases of cyphosis are of limited extent, and are restricted to the dorsal region. Such instances of limited cyphosis consist indeed merely of an increase in the natural curve of the dorsal spine. The curvature is most usually about the centre of the dorsal region, the summit of the curve being represented by one vertebra among the 5th, 6th, 7th, or 8th; and of these it would appear that the 6th dorsal vertebra is the one that most commonly marks the greatest point in the curvature.⁴ The curve, however, may involve the upper dorsal region alone, or the dorso-lumbar region alone, or all the vertebræ from the cervical to the lumbar may be implicated in the deformity. It is also to be remarked that cyphosis may coexist with lateral curvature of the spine or scoliosis. In the slighter forms of the disease, there is merely some relaxation of the vertebral ligaments, with a separation of the laminae and spinous processes, but without any gross alteration in the bones themselves. In marked and confirmed examples of this deformity, the anterior common ligament is found to be contracted, while the posterior ligaments of the column are relaxed. The individual bones have become altered so that the bodies of

¹ Traité élémentaire de Pathologie Externe, tome iii. p. 726. Paris, 1868.

² De l'Orthomorphie, ou Recherches sur les difformités et sur l'art orthopédique. Atlas. Paris, 1828.

³ Principles and Practice of Surgery, vol. ii. page 867. Philadelphia, 1881.

⁴ Bouvier et Bouland, Dict. Encyclop. des Sci. Méd., art. Rachis. (Déviations.) Paris, 1874.

the vertebræ are somewhat wedge-shaped, being thin in front and thick behind. This latter change is due not to hypertrophy of the posterior segments of the bodies, but to absorption of their anterior parts, and involves a diminution in the proper height of the column. In cases of limited cyphosis, those vertebræ alone are altered in shape that form the summit of the curve, but in the more extensive examples of the deformity a number of the vertebral segments may be involved.

It is commonly asserted that, in extensive and long-standing forms of the disease, the spine may become fixed in its false position by ankylosis.

I believe that all such cases of cyphosis, attended with bony outgrowths and ankylosis, are dependent upon chronic rheumatic arthritis, and are more properly to be considered under the head of spondylitis deformans.

In confirmed and well-marked cyphosis, from whatever cause, there is usually some corresponding deformity in the thorax. The ribs, while somewhat separated behind, tend to come more and more in contact in front, and the whole thorax tends to increase in its antero-posterior diameter at the expense of its transverse dimensions. If the curve be in the dorsal or dorsolumbar region, the thorax may incline towards the pelvis, and the ribs become more vertical in direction. The sternum, being compressed in its vertical axis, becomes bent, and usually this bend is of such a nature as to present a concavity forwards. The pelvis may follow the spine, and become so vertical as to almost efface the sacro-vertebral angle, but more commonly it tends to assume rather the horizontal direction for compensatory purposes, and thus to increase rather than diminish the angle at its junction with the spine.

Diagnosis.—The recognition of this deformity is attended with no difficulty. In the common, dorsal cyphosis the back is arched, the head poked forwards, and the chin turned towards the sternum. The shoulders are commonly raised and unduly prominent, a prominence that depends mainly upon the removal from the chest wall of the inferior angles and posterior borders of the scapulæ. In severer cases, the entire back may be arched, and progression and even standing may be impossible without some kind of artificial support. In any case, backache is frequently complained of, and the constant false position may lead to or at least augment certain visceral troubles.

Mr. Adams' remarks that, in many instances, he has observed the cyphosis of young children to end in vertebral caries with angular projection of the spine. The diagnosis of this deformity from that due to Pott's disease is, as a rule, a matter of simplicity. In cyphosis the curve is truly a curve, and not an angular prominence of one part of the spine. The curvature, moreover, is extensive and uniform. There is no muscular rigidity of the spine, but rather all the vertebral muscles are flabby, wasted, and relaxed. There is no tenderness about the part, no sign of abscess, no evidence of cord implication. Cyphosis, moreover, is most common among the aged, at a period of life when Pott's disease is comparatively unknown.²

Treatment.—Cyphosis in the young is, for the most part, readily cured, but in the old it depends, in nearly every instance, upon causes that are scarcely to be influenced by any treatment. In dealing with the spontaneous cyphosis of the young, it is necessary to remove, in the first place, the cause of the malady. Prolonged sitting or standing, or prolonged poring over books or work, must be forbidden. The general health should be, if possible, improved, and especial attention paid to the development of the muscular system. Outdoor exercise should be enforced under certain restrictions, and gymnastic

¹ Lectures on Curvature of the Spine. London, 1865, page 83.

² See under Pott's disease, *infra*.

movements, calculated to call into moderate and varied use the vertebral muscles, are to be strongly advised. The great point, indeed, to be aimed at, is the more efficient development of the muscles that should support the spinal column erect. It may be of some use to stimulate these muscles by baths, friction, or electricity, although properly directed exercise is, without doubt, the more important feature in treatment. The patient should sleep upon a flat, horse-hair mattress, and during the day should assume for a certain time the dorsal decubitus. The practice of lying for an hour or so daily prone upon the face will also be of service. Instruments and supports of all kinds should be avoided as calculated to do harm by inducing still less activity of the spinal muscles. In very severe cases, however, where the deformity is considerable, the use of instruments may be sometimes advised as a preliminary measure, and the circumstances requiring their use are identical with those that point to instrumental treatment in cases of lateral curvature, which is considered in another article. Upon the treatment of non-essential or symptomatic cyphosis, it is unnecessary to comment.

LORDOSIS.—This term is applied to a curving of the spinal column anteriorly, of such a nature that the convexity of the curve projects forwards.

With the exception of certain cases of congenital deformity, lordosis involves only a portion of the spine, and is therefore always “partial.”

It is usually met with in the lumbar region, and in that position consists merely in an increase of the natural vertebral curve.

Etiology.—Lordosis may depend upon many causes. A certain amount of lumbar lordosis may be hereditary. “Congenital lordosis” is a condition met with in certain monsters, and is accompanied by deformities that are usually incompatible with any but the briefest existence. It may be met with in any part of the spine. If in the cervical region, it usually depends upon some cranial deformity; if in the dorsal or lumbar regions, upon some thoracic or abdominal defect. The curve in these cases is usually abrupt and extreme, and in some instances the lordosis may so involve the entire spine that the head rests upon the sacrum. Some lumbar lordosis, more or less of a temporary character, may depend upon position, in cases where undue weight is thrown in advance of the line of gravity of the body. Thus it may be seen in cases of peddlers and others who continually carry trays in front of them, and in ascites, in pregnancy, in ovarian disease, and, as a somewhat more permanent condition, in great obesity.¹ The great majority of the cases of lordosis are compensatory to some other deformity elsewhere that deflects the line of gravity of the body. Thus arises a lumbar lordosis to compensate a forced flexion of the thigh, in instances of hip-disease. For like reasons is lordosis met with in congenital or unreduced dislocation of the head of the femur, in rickety deformities of the pelvis, and in rickety curvatures of the lower limbs. A lordosis may occur at almost any part of the spine to compensate an angular projection of the column developed at some other part. Cervical lordosis may depend upon the contraction of the scar after burns about the posterior part of the neck.

Mr. William Adams figures a case of lordosis associated with a lateral curvature of the column, and like cases are referred to by others.² Then again this deformity may depend upon paralysis. The paralysis that leads to lordosis may involve either the flexors of the spine (the abdominal muscles), or the extensors of the spine. In the former instance, the column is

¹ Maisonabe (*Journ. des difformités*, No. 2, 1825) gives two cases where the lordosis of pregnancy persisted after confinement.

² *Op. cit.*, page 74, fig. 10.

drawn backwards by the unresisted sacro-vertebral muscles, and in the latter instance the body is thrown back to enable the patient to walk while the abdominal muscles prevent the backward movement from being extreme. There is a form of lordosis that depends upon rickets, and that constitutes a chief feature of the rachitic spine. It will be alluded to in a subsequent paragraph.

Cases of lordosis are sometimes met with that are open to considerable conjecture as to their nature. A case of this kind was lately under the care of my colleague, Dr. Warner, at the London Hospital. The patient was a little girl, aged nine, with a considerable amount of lumbar lordosis. She was a deaf-mute, but was otherwise in all respects well developed. There was no evidence of rickets nor of syphilis. She walked with a curious and unsteady gait, like a doddering old man, placing the sole at each step flat upon the ground at once. There was no definite paralysis of any muscles, and the child would run and play about all day without becoming unduly tired. She was very intelligent. The hip-joints, and all the muscles of the lower limbs and back, appeared normal. It was asserted that the lordosis had been noticed since the child had learned to walk. The greater part of the spinal deformity disappeared on suspension, or when the child was placed in the recumbent posture. The condition remained unaltered during the year or so that the child was under observation. In this case, the defect would appear to have been in the motor nerve system, and whatever the defect might be, it was probably congenital, or developed soon after birth.

Pathological Anatomy.—In marked cases of long duration, the posterior spinal ligaments are found contracted, and the anterior common ligament stretched. The spines and transverse processes of the affected part may touch, or be crowded together. The intervertebral disks may be increased in thickness in front, but it does not appear that any absorption of the posterior segments of the bodies is usual, or even common. The sacro-vertebral mass of muscles is often found contracted and rigid; and the psoas muscle, on the other hand, in a state of fatty degeneration from disuse. In lordosis of the lower portions of the spine, the pelvis tends to become more vertical, and the sacro-lumbar angle more prominent. If the dorsal region be much involved, the thorax may become deformed by a diminution in its antero-posterior diameter. In some cases the spinal column may be rigidly fixed in the abnormal position by a bony ankylosis of its parts, although such a circumstance is of much less frequency in lordosis than it is in the opposite deformity before treated of.

This ankylosis may take the form of stalactitic outgrowths from the transverse processes and spines, of such a character as to bind adjacent vertebræ together. In other cases the articular processes may be ankylosed, and in another set of instances bony outgrowths from the margins of the bodies themselves may serve to immobilize the affected portion of the spine. Du Verney¹ records a case of extensive lordosis of the dorsal and lumbar regions of the spinal column, where the intervertebral disks were ossified, and the whole spine thereby rendered rigid. The account given of this case, however, is very meagre. It is probable that in some of the instances of lordosis, characterized by the outgrowth of stalactitic processes, a chronic rheumatic arthritis of the part is the cause of the condition.

The *diagnosis* of this curvature is extremely simple. It is impossible to be mistaken, if in any degree well developed. The in-curved back, the erect carriage, the prominent belly, are all very familiar as usual concomitants of lordosis in its most common position—the lumbar spine. A more difficult

¹ *Traité des Maladies des Os*, tome ii. p. 117. Paris, 1751.

matter is to determine the cause of the deformity; but as this subject would involve a discussion of the symptoms of many very difficult diseases, it can hardly be dealt with in this place.

The *treatment*, in perhaps the majority of instances, is simply negative. In many cases the lordosis is compensatory to some permanent and incurable deformity, and is an advantage rather than a detriment to the patient. In few cases, indeed, is it of itself a cause of any great trouble to the individual who presents it. It would be obviously absurd to attempt to treat the lordosis depending upon abdominal tumor or pregnancy, although the curvature sometimes due to obesity may perhaps be lessened by supporting the pendulous abdomen with a proper belt. Cases due to prolonged false position of the spine in connection with some special employment, may obviously be relieved by discontinuing that employment. Lordosis depending upon muscular weakness may be treated on the general plan advised in speaking of cyphosis. In no cases—except, perhaps, in those of confirmed paralytic lordosis—are instruments of any kind desirable, and even in these cases they can do little more than help to retain the spinal column erect.

THE RACHITIC SPINE.—Before leaving the subject of antero-posterior curvatures, some slight notice may be taken of the common changes in the spinal column in rickets.

For a full account of the pathology of this disease, and of the various deformities which it causes, the reader is referred to the article on Rachitis,¹ and to that on Orthopædic Surgery. The spine in rickets may become the seat of certain curvatures that are nearly always in the antero-posterior direction. The nature of the curve is, to a great extent, influenced by the age of the patient at the time of its commencement. It must be remembered that at birth the vertebral column is without curve. The natural curve, such as it is, of infancy, is a general curving of the back, a slight cyphosis. This curve is seen when the infant is placed in the sitting position, and is the natural effect upon the column of the superincumbent weight. The earliest deformity of the spine in rickets, the deformity that appears at a time before the child begins to walk, is simply an exaggeration of the natural infantile curve. When the rickety child assumes the sitting posture, the whole back becomes curved from the neck to the loins. This curve is by no means permanent, and, indeed, at once disappears if the patient be suspended by the arms. It is due simply to a disproportion between the weight the column has to support, and the means it possesses to effect that support. The essential and primary defects in the column itself depend upon certain changes in the bodies of the vertebræ, upon certain defects in their growth and method of development, in the yieldings of enfeebled ligaments, in the failure of still more enfeebled muscles, and, as some would add,² in an abnormal softness of the intervertebral disks. The cyphosis of rickets is most marked in the lower dorsal region, is seldom severe, and is not very apt to become permanent and irremediable. Indeed, as the child begins to walk, fresh mechanical influences are brought to bear upon the column, and the abnormal curvature may be replaced by the normal curves of the developed spine, or by an exaggeration of those curves. If the child has commenced to walk at the time that the rickety change involves the spine, then the deformity produced will, as first hinted, consist in an exaggeration of the normal curvature that should develop when the child is first able to support the body in the erect position. Thus a lordosis in the lower segments of the spine

¹ See Vol. I. page 255.

² Senator, Art. Rickets, Ziemssen's Cyclopædia of Medicine, vol. xvi. page 194.

will appear in the place of a cyphosis in the middle segment. Thus, as Mr. Haward expresses it, cyphosis is the curvature of a rachitic infant, lordosis the curvature of the older child.¹ It must also be borne in mind that spinal curvatures may develop in rickets as the consequence of a deformed thorax, a deformed pelvis, or deformed extremities.

In the matter of *treatment*, it is only necessary to observe that the *general* measures recommended in the article on Rachitis must be carried out. With regard to any *local* treatment, the recumbent position should be advised, to be maintained every day for a period that must vary according to the age of the patient, the degree of the curvature, and the general circumstances of the case. As the child's general health improves, the vertebral muscles must be encouraged in their development by moderate and careful exercise; and this end may possibly be aided by friction of the parts, by baths, and, in some cases, possibly by galvanism. In no instance should any apparatus be applied. If the curve be rapidly on the increase, that tendency must be met by insisting on the patient maintaining as far as possible the recumbent posture. To encase the spine in any rigid apparatus would but foster still further inactivity in the muscles, and favor a still further degree of feebleness in their action. If the disease have ceased all active progress, and the curvature alone remain, a return to the normal condition of the spine can be more readily and more surely brought about by improving the muscular condition of the back than by applying an apparatus. The apparatus, while it might remove the *appearance* of the curvature, would still tend to perpetuate its potential existence, and possibly leave the column as deformed at the conclusion of the treatment as it was at the commencement.

The subject of *scoliosis*, or *lateral curvature of the spine*, is treated of in the article on Orthopædic Surgery.

SPONDYLITIS DEFORMANS.

The term "spondylitis," from the Greek *σπόνδυλος*, means simply inflammation of a vertebra, and is therefore equivalent to the term "vertebral osteitis."

In this sense the word was first used, and it is still so employed by many, although the term has been by no means generally accepted in English surgical literature. The inflammatory process, when it involves the bones of the spinal column, is apt to assume many aspects and to lead to several very distinct clinical conditions. Although it might be well, from a pathological point of view, to consider all inflammatory changes of the vertebral bones under one common heading, such a course would be extremely inconvenient when the clinical aspects of the disease came to be considered. It might be, perhaps, more scientific to consider such conditions as Pott's disease, osteo-arthritis of the occipito-atloid joint, or necrosis of the odontoid process, under the general heading, "spondylitis," but upon clinical and descriptive grounds the arrangement would not be advisable. The use of the term therefore—in at least its proper sense—would appear to present few and doubtful advantages.

With regard to the term "spondylitis deformans," it would be assumed, from what has just been said, that it referred to an inflammation of the vertebral bones leading to deformity. It would be a synonym therefore for such an affection as Pott's disease. But by the aid of that mysterious power that appears to influence the selection of scientific terms, the title spondylitis deformans has been applied to one definite disease, viz., chronic rheumatic

¹ Treatise on Orthopædic Surgery, page 100. London, 1881.

arthritis of the vertebral articulations. There are not many who would allow this disease to be ranked with simple inflammations; and even if it were an inflammatory change, it could hardly be said to be essentially a change involving the bones. Still the term has been accepted, and very generally accepted, and, as has occurred before, scientific accuracy must give way to custom.

Spondylitis deformans, then, is the term used to denote chronic rheumatic arthritis of the vertebral column. An account of the general pathology and symptoms of this disease will be found in the article on Diseases of the Joints.¹

ETIOLOGY.—This disease is met with usually in later middle and advanced life, and slight grades of the disease are of much more common occurrence than is generally supposed. In the subjects, for example, brought to the dissecting-room of the London Hospital Medical College, I have met with many examples of this vertebral affection, and believe that a slight degree of the disease is one of the commonest causes of the cyphosis of old age. *Spondylitis deformans* is sometimes met with at an earlier period of life. Dr. Allen Sturge² records a severe case in a man aged 26, and states that Eulenberg has met with a typical instance of the disease in a patient aged 12 years. Dr. Todd also mentions the case of a young girl who had chronic rheumatism of all her joints, and ankylosis of the spine. Many instances have been recorded in patients about thirty.

With regard to sex, the affection is much more commonly met with among males than among females. Occupation would appear to have some influence in the etiology of the disease, *spondylitis deformans* being more common in those whose employment involves frequent stooping or arching of the back.

As may be supposed, it is of more common occurrence among the poor than among the well-to-do, and its appearance may in some cases be very possibly influenced by exposure to cold and damp. In at least the severe cases of *spondylitis*, there is a history of rheumatic tendencies in the patient's family.

PATHOLOGICAL ANATOMY.—In this disease the spine becomes curved and rigidly fixed in the abnormal position. Any part of the column may be involved, and in not a few instances the entire spine has shown evidence of the disease. The lower dorsal and lumbar regions are, however, the portions most commonly affected, and next in frequency comes the upper cervical region.

The pathological changes are identical with those that indicate chronic rheumatoid arthritis in other parts, and are marked in the main by absorption of the articular cartilages, by the outgrowth of nodular masses of dense bone, and by the occurrence of a certain amount of true or false bony ankylosis.

Among the earliest changes in *spondylitis*, is some absorption of the intervertebral disks, and the development of osteophytes from the bodies of the vertebræ. These osteophytes are most common at the sides of the bodies, between the edge of the anterior common ligament and the transverse process. They grow as rounded masses from the contiguous margins of adjacent vertebræ, and, meeting opposite the middle of the intervertebral disk, become locked together, and in time may fuse in firm, bony ankylosis. In the mean while the disk between the vertebræ becomes shrunken, friable, and of a dusky color. In some cases it may entirely disappear, and the vertebræ it once served to separate may then become firmly ankylosed together.³ In this way

¹ See Arthritis Deformans, page 369.

² Clinical Society's Trans., vol. xii. page 204. London, 1879.

³ Bouvier et Bouland, Dict. Encyclop. des Sc. Méd., art. Rachis (déviations), Cyphosis.

portions of the column may become converted into a solid, bony mass. The lateral osteophytes just alluded to may attain considerable size, and are often singularly symmetrical on the two sides. In addition to these outgrowths, or independent of them, irregular, bony masses may form in front of the vertebræ, apparently in the substance of the anterior common ligament, and may also serve to bind contiguous bones together. Such a bond is more often effected by the locking of the osteophytic processes than by their actual fusion, although the latter condition is to be met with.

With regard to the articular processes, they become denuded of cartilage; the bone, thereby exposed, becomes more or less eburnated; osseous masses form about the rim of the bone; and the process may end in true bony ankylosis, or in a firm locking of the joint by the development of the osteophytic masses. Dr. Hilton Fagge¹ records a case of rigid cyphosis in a man aged 34, where there was complete bony ankylosis of the articular processes in the dorsal region, together with firm union of the corresponding laminae and spines by means of coarse, new bone. The bodies in this case were free from any osteophytic growth, but were so rarefied and wasted that the spine was fractured after death by the simple act of placing the body in the coffin. Bouvier and Bouland, speaking of ankylosed cyphosis, allude to the occurrence of this fusion of the laminae and spinous processes, but insist, at the same time, upon its extreme rarity.² In some instances the costo-vertebral joints are affected, and the ribs become firmly ankylosed to the spine. As a result of the above-mentioned changes, the column becomes arched posteriorly, and a more or less extensive cyphosis is developed. This curve is generally quite regular, and its extent will, of course, depend upon the extent of the disease.

I have met with two or three instances, in specimens obtained from the dissecting-room, where the cyphosis was associated with a certain amount of lateral deviation, the lateral curve being, like that in the antero-posterior direction, quite rigid. The fixity of the column in its false position is a very marked feature of the disease. The changes observed in the bones themselves are all usually most marked about the summit or greatest concavity of the curve.

As a result of the curvature, of the bone changes, of the absorption of the intervertebral disks, etc., the entire column becomes diminished in height; and, as a result of its rigid condition, the muscles about the back atrophy, and often become very shrunken. The bony masses that are developed about the affected district may press upon the nerves, as they issue from the intervertebral foramina, and lead to a limited paralysis; and, according to Senator,³ the spinal deformity may be of such a character as to cause compression or irritation of the cord with its attendant consequences.

Spondylitis deformans in the upper cervical region is attended with like changes in the atlo-occipital and atlo-axoid joints. The articular cartilages and the intervertebral disks may become absorbed, osteophytic deposits form about the rim of the affected joint-cavities, and a rigid ankylosis, that may depend upon fusion of the bones involved, is the common and the final result. In some cases, where the axis is conspicuously affected, the odontoid process may be found irregular in outline and greatly enlarged. No curve is formed when the disease attacks this region, but the joints become fixed, and the movements of the head being thus more or less restricted, a constrained position is assumed. Lastly, at least one case has been put on record of degeneration of the cord following disease in this portion of the spine.⁴

¹ Trans. Path. Society, vol. xxviii. p. 201. London, 1877.

² Loc. cit.

³ Ziemssen's Cyclopædia of Medicine, vol. xvi. 1877.

⁴ E. Rotter. Deutsches Archiv f. klin. Med., Bd. xiii. S. 403. 1874.

SYMPTOMS.—The disease usually commences with pain in the back. This pain may be severe and radiating, and of the character of rheumatic pains. In Dr. Sturge's case the onset of the pain was so sudden and severe as "to take away the patient's breath." It will soon be noticed that the back is becoming stiff, and that the patient has some little difficulty in stooping, or in moving the head. There is no tenderness of the parts, nor is there of necessity any actual pain when movements of the spine are attempted; but the stiffness is very conspicuous and irksome, and some "rheumatic pains" about the back may be more or less constant. After a prolonged rest the column will usually appear unduly stiff; and on the other hand, after extensive movements, the back may, in the earlier stages of the disease, appear more lissome, and be moved with less discomfort. As time goes on, the patient begins to lose his upright carriage; he appears diminished in height, acquires a constant stoop, and develops an antero-posterior curvature of the spine, with the convexity backwards. The cyphosis that results from this disease is generally well marked, of regular outline, and often of considerable extent. Its conspicuousness, moreover, is accentuated by that wasting of the sacro-vertebral muscles that in time ensues. The curve may be of such a character that the patient prefers to support himself with a stick when walking; the abdomen projects, and the shoulders appear often unduly prominent, owing to the scapulæ being more or less separated from the chest-wall in consequence of alterations in the thorax. If the upper cervical vertebræ are involved, the movements of the head become limited to a variable extent, the chin is poked forwards, and that constrained position is assumed which is familiar in cases of disease about the summit of the column. The rigidity of the spine, when the malady is well developed, is usually very marked, and may be absolute.

The thorax becomes more or less rigid, and may assume the deformity detailed in the paragraphs on "cyphosis." The fixity of the ribs may depend not only upon the alteration in the dorsal spine, or the formation of osteophytes about the costo-vertebral joints, but upon actual ankylosis of those joints. In the latter instance the breathing is entirely abdominal, as it was in the case recorded by Dr. Hilton Fagge, and alluded to above.

In spondylitis deformans there are usually evidences of chronic rheumatoid arthritis in some other part or parts of the body.

The duration of the disease varies. Its course is always chronic, and is to be estimated by years. The lighter grades of the disease have probably little effect in shortening the patient's life, and, as is well known, a good old age may be attained by those whose backs have been stiff and painful, and bent, for a good number of years. When the disease occurs in early or in middle life, the prognosis is by no means as favorable. Life may be considerably curtailed by the malady, and indeed, if it assume by any means a severe form, death usually results in a comparatively few years.

As regards *treatment*, it can only be asserted that the condition is incurable, and that neither local nor general measures are of any permanent or substantial value. Some relief may be given by the treatment, such as it is, that is usually advised in chronic rheumatic arthritis, and an account of which will be found elsewhere.¹

CARIES AND NECROSIS.

Caries and necrosis are both of common occurrence in the spinal column: but the former is, of the two, infinitely the more frequent. The large amount

¹ See Vol. III., page 489, *supra*.

of cancellous tissue that enters into the composition of the vertebræ, will explain the greater tendency of the column to caries, and for the same reason it follows that the bodies are the usual parts attacked by the malady. Necrosis, on the other hand, is chiefly met with in the posterior segments of the spine, and when occurring in the anterior portions of the column usually implicates such parts as contain much compact tissue, and therefore principally involves the first and second cervical vertebræ.

The matter of *caries* is fully discussed in the sections on Pott's disease and Disease of the Atlo-axoid region.

The principal and most frequent examples of *necrosis* of the spine are also detailed in those sections; and it only remains here to allude to such cases of necrosis of the column as cannot be well referred to either of these clinical divisions. These cases are but few in number, and are due probably in all instances to injury. Thus I have seen necrosis of several of the dorsal spines follow upon a severe laceration of the back, that had exposed and injured those processes.

A like necrosis has followed upon certain fractures and dislocations of the spine attended with crushing and comminution of the bones.

Mr. Bickersteth records a remarkable case of a man, aged twenty-two, who was shot in the neck. The lesion involved the fifth and sixth cervical vertebræ. After an interval of some months he became the subject of dysphagia and paralysis of both arms. The wound was open, and there was intense inflammation of the pharynx. He ultimately expectorated two small pieces of bone, and a dense mass of tissue that was discovered to be an intervertebral fibro-cartilage. A perfect recovery followed, although some stiffness of the neck persisted.¹

INTERVERTEBRAL ARTHRITIS.

This term obviously implies inflammation of the joints between the vertebræ, and includes not only arthritis of the true joints between the articular processes, but also inflammatory affections of the intervertebral disks. The term is too general, and too wide in its application to be of use in any treatise that is founded upon a clinical rather than a pathological basis. It might be of great advantage in the light of pure pathology—to consider all forms of vertebral arthritis under one common heading—but such an arrangement would tend to confuse well-marked and familiar clinical outlines, and would be in direct opposition to commonly accepted notions of the varieties of vertebral disease.

The intervertebral joints that are the most commonly involved are those between the axis and between the latter bone and the occiput. These affections are fully discussed in the chapter on Diseases of the Atlo-axoid Region. A special form of intervertebral arthritis is considered under the heading Spondylitis Deformans.

The principal and most common, inflammatory, or destructive processes in the intervertebral disks, are considered in the section on Pott's Disease, and it is necessary, therefore, in this place to do no more than call attention to some rare aspects of intervertebral arthritis that cannot be included under any of the above-mentioned headings. These examples of the disease are twofold: (1) Arthritis of the true joints of the spinal column following upon injury, and (2) certain peculiar cases of perforation of an intervertebral disk.

(1) The vertebral column is frequently the seat of concussions and sprains.

¹ Medical Times and Gazette, vol. i. 1862, page 614.

These injuries must involve to some extent at least the joints that connect the various vertebræ together. If the more superficial joints of the body are exposed to sprain or contusion, they commonly enough become the seat of synovitis, and there is nothing in the structure of the joints between the articular processes of two vertebræ that exempts them from a like consequence. I believe, indeed, that simple synovitis of certain of the synovial joints of the spine, is common after sprains and contusions of the back, and that such a condition can probably explain the long-continued pain and stiffness that often persist after such injuries, and that are usually so very well localized. There is no reason to suppose that this synovitis is different from other forms of synovitis. It may be acute or chronic; and it may end in resolution or pass to suppuration. I am aware of no actual demonstration of simple synovitis of the vertebral joints; but many cases have been recorded of suppurative synovitis of these joints that has followed upon sprains and like lesions. The main symptoms are long-continued, local pain, and rigidity from the painfulness of movement and some amount of muscular contraction. I am well aware that these symptoms may occur in cases where the muscles only are lacerated or contused, and perhaps the ligamentous structures torn, but there is nothing to disprove the suggestion that in some instances these symptoms may be due to intervertebral synovitis. Shaw states that not only may this synovitis of the joints between the articular processes go on to suppuration, but the purulent collection thus formed may cause limited paralysis by pressure upon the nerves as they issue from their respective foramina. Moreover, the joint-abscess may burst into the spinal canal and lead to paraplegia and death.¹

(2) Dr. John Ogle has placed on record two remarkable cases of peculiar perforation of an intervertebral fibro-cartilage that in each instance led to death from implication of the medulla spinalis.

The first case occurred in a man aged 50, who had presented no distinct evidence of spinal mischief until one day, while at his meals, a piece of a mutton bone became impacted in his gullet. This was easily disgorged, but the act was immediately followed by a paroxysm of coughing, during which much pus was brought up. He experienced also much pain in the neck. In process of time he became paralyzed—first in the upper and then in the lower extremities—and gradually sank, sensation having become impaired some few days before death. At the autopsy, a hole was found in the posterior wall of the gullet, that led directly to a perforation in the fibro-cartilage between the fourth and fifth cervical vertebræ. The perforation presented an ulcerated appearance, and had gone right through the disk, and so opened into the spinal canal. The cord and its meninges were inflamed.²

The second case was that of a woman, aged fifty-two, who suffered from post-pharyngeal inflammation connected with some slight erosion of the surface of the bodies of certain cervical vertebræ. She died from spinal arachnitis, and the post-mortem examination revealed a perforation in one of the cervical fibro-cartilages, that had extended back and opened into the spinal canal.³

POTT'S DISEASE OF THE SPINE.

NOMENCLATURE.—There is a well-known affection of the vertebral column that is most common in the young, and that is marked by certain very defi-

¹ Holmes's System of Surgery, 2d ed., vol. ii. page 367.

² Path. Soc. Trans., vol. iv. 1853, page 27.

³ Ibid., vol. xv. 1863, page 1.

nite, general features. The spine becomes rigid and tends to develop an angular deformity, an abscess with some peculiarities may form, paraplegia may ensue, and, after death, the anterior segments of the column will be found more or less extensively damaged by a destructive process. Various names have been given to this disease, and some explanation may be offered as to why the particular name that is adopted here has been selected. Among the terms applied to, or associated with, this malady, may be mentioned caries of the spine, vertebral tuberculosis (Nélaton), vertebral arthritis (Ripoll), osteitis of the spine, angular curvature of the spine, and Pott's disease.

The term "Caries of the spine" is very definite, but its very preciseness is an objection to its use in the present instance. The morbid process in this malady is indeed, in the vast majority of all cases, a caries of the bone, but at the same time cases are recorded where the bone has been exempt and the disease has been limited to the intervertebral fibro-cartilages. On the other hand, it can by no means be said that all cases of vertebral caries are associated with the general symptoms above mentioned, so that, if the clinical entity of the "Pott's disease" is to be maintained, the term now criticized is both too narrow and too wide. The terms "vertebral tuberculosis" and "vertebral arthritis" are to be discarded, inasmuch as they commit the user to certain very definite and limited views, in the one case as to the nature of the morbid process, and in the other as to its primary seat. The term "osteitis of the spine," on the other hand, is too indefinite to express the peculiar clinical attributes of the present affection. Inflammation is common enough in the bones of the column, but it is only in a comparatively small number of instances that that process leads to the definite disease known by many as Pott's disease. It would certainly be no gain to clinical surgery to forcibly associate this disease with such other forms of osteitis of the spine as necrosis of the spinous processes after injury, or inflammation of the odontoid body. The common and much used term "angular curvature" is open to the gravest objections. In the first place, the term is in itself ridiculous, involving, as it does, an obvious contradiction. An angular curve must, from a geometrical point of view, be classed with a square circle, or a round triangle. Then, again, the angular deformity is but one symptom of the disease, and that symptom, be it noted, not of necessity a constant one. Moreover, unwholesome ideas as to the treatment of the disease may be perpetuated by the prominence thus given to an important but isolated symptom. Finally, I would urge the use of the term "Pott's disease" upon these grounds. The meaning of the expression is well known, and its clinical associations are familiar. The term is extensively employed, not only in England and America, but especially on the Continent. In France, indeed, the title "*mal de Pott*" is the generally accepted name for this malady. Then, again, the term commits the user to no particular pathological opinion, and may be used by men holding the most opposed views in pathology, to express the same association of clinical features. Lastly, the term serves to perpetuate the name of a man who well deserves the honor, and who was the first to remove this disorder of the spine from the region of a confused ignorance, and from the especial province of the quacks.

ETIOLOGY.—*Age*.—Pott's disease may occur at almost any period of life. It has been met with in infants in arms, and in patients far advanced in years. Bryant,¹ indeed, details an instance where the disease attacked a fœtus in utero. The specimen is preserved in Guy's Hospital Museum, and shows "the bodies of three or four of the dorsal vertebræ . . . clearly fused

¹ Manual for the Practice of Surgery, vol. i., 2d ed., p. 278.

together from disease, giving rise to angular curvature." Cases, however, of Pott's disease at these extreme periods of life are exceedingly rare. The malady is usually met with between early childhood and adolescence, and in the great majority of all cases the disease commences between the ages of two and ten years. Instances are met with of the disease commencing in adults, but such instances are comparatively few, and the onset of Pott's disease in patients past middle life is very rare. This affection is indeed essentially a disease of childhood.

Sex.—Sex appears to have little or no influence in the etiology of the disease. It has been asserted by many—and especially by those who urge a traumatic origin for Pott's disease—that it is more common in male than in female children. My own observation would lead me to believe that it is equally common in the two sexes, but Mr. Fisher's¹ statistics show a greater number of cases among females. These statistics are probably the most valuable that have been published. Of 500 cases of angular deformity treated at the National Orthopædic Hospital, 261 were in females and 239 in males. Allowing for the preponderance of females over males in the general population, these figures would make it appear that the disease is, perhaps, equally common in the two sexes, and would at least correct the assertion that the malady particularly affects boys.

Constitutional Condition.—Pott's disease is usually met with in unhealthy children, and especially in those who present that phase of ill health known as scrofula. It must be confessed that on this point there has been no small amount of dispute, and while some have urged that every case is directly due to scrofula, others have maintained that that diathesis has nothing to do with the production of the disease. Many of these discrepancies are to be explained by the various conceptions that are held as to the nature of struma. Those who expect every patient with Pott's disease to present a certain physiognomy, will certainly be disappointed, as will also those who may expect every such patient to present glandular disease, or to come of a decidedly "tubercular" stock, or to finally die of some tubercular malady. Scrofula, as I have tried to demonstrate in a recent work on the subject,² is rather a tendency to a peculiar form of chronic inflammation. Of the character of this inflammation I will speak subsequently. The diathesis is rather to be estimated by certain morbid tendencies in the tissues, than by any peculiarity of feature or descent. In support of the assertion that angular deformity is most usually met with in the strumous, I would draw attention to these facts. In a great number of instances, the patient's immediate relations are the subjects of acknowledged scrofulous disease. In many instances there is a history of phthisis or of tuberculosis in the family. The patient often exhibits some other evidence of a strumous habit. This may be seen by a tendency to chronic catarrhs, by the occurrence possibly of certain skin affections, or by a disposition, it may be, to certain glandular enlargements. In not a few instances I have notes of cases where the spinal disease was cotemporary with, or preceded or followed by, some such gross, strumous ailment as "white swellings" of a joint, or caries, or necrosis of some bone. Lastly, as I shall point out when dealing with the pathology of this disease, the morbid changes that take place in the vertebræ are very often identical with changes occurring in acknowledged scrofulous disorders. Some authors have objected to Pott's disease being classed among strumous affections, because many of those who suffer from the disease do not present at the same time great glandular swell-

¹ Essays on the Treatment of Deformities of the Body, p. 11. London, 1879.

² Scrofula and its Gland Diseases. London, 1882. See also my article on "Scrofula," in Holmes's System of Surgery, 3d ed. London, 1882.

ings, or other strumous malady. A few do show these complications, while the majority do not; and the condition of these latter is, I think, to be explained by that antagonism that appears to, exist between the various strumous disorders, and that does not favor the appearance upon the same patient, and at the same time, of more than one gross manifestation of the disease. In the book just alluded to, I have endeavored to fully demonstrate this antagonism. While then, I would not for one moment insist that all the victims of Pott's disease are of necessity scrofulous, I would urge that the majority of such patients present reasonable evidences of this diathesis. I have, for example, met with several instances of this spine-affection in children who have appeared in perfect health as regards their general condition, and who have moreover presented no suspicion of struma in their families; but such instances are exceptional. Lastly, I believe it will be very generally allowed that Pott's disease is more common among the poor than among the rich, or well to do, and that it is most common in association with those general conditions which are the most favorable to the production of struma. Some few writers have maintained that angular deformity may be due to rheumatism or gout, but there would appear to be little or no foundation for this statement. On still scantier grounds has masturbation being assigned as a cause of this disease.¹

Injury.—There can be no doubt that injury bears an important part in the etiology of Pott's malady. In those cases in which the disease attacks children who are apparently in robust health, and who present no constitutional taint of any kind, I believe that an injury is to be assigned as the actual cause of the mischief in the spine. In those cases, moreover, in adults who appear to be in all other respects in perfect health, a history of injury, distinct and grave, is seldom, if ever, absent. The frequency with which the disease would appear to commence about the junction of a vertebra with its interarticular fibro-cartilage, supports the theory of an injury as an essential cause. For it is well known that the point of junction of a rigid with an elastic segment of a column is a point of weakness. Allowing, then, that an injury is, in certain cases, an essential cause of angular deformity, I doubt if the majority of surgeons would go further, and assert with Dr. Sayre that this disease "is almost always, if not always, produced through some injury to the bone or cartilage."² There must be very few children who reach the age of ten years without having met with some accident, trifling although it may be, in which the back has been, directly or indirectly, involved. Any inquirer who starts with a bias in favor of injury as an essential cause of Pott's disease, will not lack material to support his opinion. The only question is as to the value of that material. Of how many children at the age of ten, could it not be probably said that "so many months ago it fell and hurt its back," or "had a bad tumble," or "had something strike it in the back?" Those who maintain the importance of injury in this disease, must also accept the onus of explaining why Pott's disease is not more common than it is, and why a given injury will produce the malady in one child, while it has no permanent effect upon another. In scrofulous children, in children already predisposed by heredity or acquired defects to certain phases of chronic inflammation, it is easy to understand that a very slight lesion may excite a carious action in the vertebræ. Whether such a lesion is essential, or not, it is difficult to say, and still more difficult to prove. There is the further question as to whether this lesion must of necessity be "an injury" in the usual meaning of that word, or whether it may not be caused by undue use of the part, by dispro-

¹ See, for example, South's edition of Chelius's Surgery, vol. i. page 280.

² Spinal Disease and Spinal Curvature, p. 2. London, 1877.

portion between the strength of the column and the weight it maintains, or by undue pressure exercised upon some especial part of the vertebral segments. Lastly, if traumatism were so essential a feature in Pott's disease, it would not be unreasonable to expect that some definite relation should exist, other things being equal, between the injury and the consequent disease. But no such relation exists. A severe, extensive, and acute form of spinal caries may occur with the absence of a history of any definite lesion, while, on the other hand, a severe injury to the back may be attended with no ill results other than those immediately connected with the accident.

Considered generally, the etiology of Pott's malady bears a very striking resemblance to the etiology of "white swelling," or strumous joint disease, and there is an almost complete identity between the various opinions that have been advanced as to the causes of the two complaints.

PATHOLOGICAL ANATOMY.—The morbid change that constitutes the essential feature of Pott's disease is, with some slight reservation, a caries or molecular disintegration of the vertebral bodies. This change may attack any part of the column, but is more commonly met with in the lower dorsal region than elsewhere. In some rare cases, two distant parts of the spine may be involved at the same time, or may be attacked independently at different periods. An example of this latter circumstance is recorded by Shaw.¹ Although the disease may be limited to a single vertebra, such an occurrence is rare, and in most instances many of these bones are involved, and often in very varying degrees. Bryant² reports a case where no less than twelve vertebræ were involved. The morbid process nearly always commences in the bone; it may, however, commence in an intervertebral fibro-cartilage, and there are some who assert that the earliest change may take place in the periosteum, or in the spinal ligaments. There does not appear to be any positive evidence to support the theory of the origin of this disease from the two last-named structures.

The whole pathological process in Pott's disease may be divided into two distinct periods or phases: first, the period of destruction or softening; and, secondly, the period of repair. The changes themselves can be best considered (1) as they affect the bone, and (2) as they affect the intervertebral cartilage.

I. PERIOD OF DESTRUCTION OR SOFTENING.³—(1) *Changes in the Bones.*—These changes consist in a caries that has some few peculiarities. The morbid action is singularly limited to the anterior segments or bodies of the vertebræ. The body may be extensively and even entirely destroyed, yet will the morbid action have little or no tendency to extend to the posterior segment of the bone, to the laminae, the pedicles, and the various processes; seldom, indeed, does it extend as far posteriorly as the articular processes and intervertebral joints, although, as a somewhat rare occurrence, these parts of the bone may be involved. The disease may commence in any part of the body of the vertebra, or at several parts at one and the same time. Most usually the earliest changes would appear to be in the anterior part of the bone, not far from the anterior surface. Another common spot for the commencement of the disease is that part of the body of a vertebra nearest to the intervertebral disk. It must be remembered that this part of the centrum is an epiphysis, and the disease would appear in many cases to begin as an epiphy-

¹ Holmes's System of Surgery, 2d ed., vol. iv. p. 112. London, 1870.

² Manual for the Practice of Surgery, vol. i. p. 277.

³ After describing the process as it affects the bones and cartilages it will be well to include under this heading an account of the "deformity" and the "abscess."

sitis, as it is called. Certain it is, that for some time the mischief may remain limited to that portion of the bone which corresponds to the epiphysis. Follin and Duplay state that the earliest change in Pott's disease is often to be noticed about the posterior part of the body, near its junction with the pedicles; and other observers have cited the centre of the bone as a frequent spot for the commencement of the disease.

The change itself would be described, in the language of the text-books, as an *osteitis interna*, or as a *caries fungosa*, and, very briefly, the following are the alterations that are to be noted in the part: A certain area in the cancellous substance of a vertebral body becomes congested, and all the spaces in the bone become engorged with blood. Into the immediate cause of this limited congestion we cannot now enter. This vascular disturbance is soon followed by grosser changes, which consist, in the main, of two distinct processes—a softening and breaking down of the bone structure, and a development of certain fungous granulations. To properly appreciate these changes, it is needful to recall to mind the fact that two elements enter into the formation of bone, viz., inorganic matter and an organic matrix. The relation which these two elements bear to one another may be compared to the relation that exists between the plaster and the laths in a lath-and-plaster wall. Just as the laths support or hold together the plaster, so does the organic matrix of bone serve to support the inorganic elements or lime-salts. Now, it is obvious that the morbid process in inflammation of bone must be limited to the organic matter of the affected tissue, and that the inorganic material can take none but a purely passive part in any pathological change. Inflammation, to speak roughly and generally, has a tendency, in the first place, to soften the tissue that it invades. When inflammation attacks bone—or, rather, when it attacks the organic matter of a bone—it softens that material, and one might almost say that it dissolves it. The result of such a change is, that the matrix is no longer able to support the inorganic elements, and the structure crumbles down, just as would a lath-and-plaster wall if it were possible by some process to dissolve out the laths without seriously disturbing the plaster. It is needless to say that this softening and disintegrating change is no mere chemical process, but is brought about by active changes in the part itself, and in the bloodvessels that are concerned in its nutrition.

Into the minute features of the process, it is unnecessary here to enter. Suffice it to say that the partition walls between neighboring cancellous spaces are broken down, and that one large and irregular space results from the fusion of several small ones. Thus, the bone becomes lighter and more spongy, more cancellous apparently in its structure, and more friable undoubtedly to the touch. These bony spaces are by no means empty, nor have they for contents but the *débris* that has resulted from neighboring disintegration. On the contrary, they are occupied by a “fungous” granulation-tissue that has been derived partly from the altered cell-elements of the bone, and partly from an exudation provided by the bloodvessels in the area of disease. The “fungous” character of these granulations can hardly be said to be apparent until there is such a loss of parts that they find themselves projecting from a free surface. These granulations are very intimately connected with the disintegration of the bone. Indeed, they appear to penetrate the parts and carry destruction in their wake. It is by them that the process spreads, and it is to them that the pathologist has turned for a clue to the nature of the entire process. When the disease reaches the periosteum, the granulations are described by Lannelongue as perforating that membrane, and as piercing it, as it were, often at many points. The periosteum, readily altered, would become a part of this granulation-material, and would in time be destroyed, as the bone had been destroyed. Thus would the bone be bared and an erosion in

its substance be exposed, or a deeper cavity in its interior be made manifest. Such are the main features of this caries fungosa. The mischief most usually would appear to commence at some little distance below the surface of the bone, but in certain instances the layer of compact bone next to the periosteum has been credited with exhibiting the earliest evidences of disease. Possibly—as above remarked—the mischief may sometimes commence in the periosteum.

The gross and visible result of the carious change, however, is this: Irregular cavities are formed in the diseased vertebral bodies. There may be several cavities in the same centrum, or one only, and the situation of the loss of substance may vary considerably. If the cavity forms deep down in the bony substance, it may continue to increase until nearly all the cancellous portions of the body are destroyed, and nothing is left but the outer shell of compact bone. This probably soon gives way, and the cavity opens upon the surface. In other cases the destructive action may early make its way towards the surface of the bone, and lead to an excavation in the bone that, while comparatively small, is yet deep. It is remarkable that the carious process tends, with the very rarest possible exceptions, to progress towards the anterior surface of the bone, and not towards that surface that bounds the spinal canal.

It will be seen that these cavities and excavations will vary greatly in appearance. There may be a cavity deeply hidden in the bone. There may be a cavity near the surface, whose walls are formed partly by bone, partly by thickened periosteum and ligament. In other cases the anterior surface of the bone is laid bare, and thus are exposed erosions varying in extent and depth, or deeper and more cavernous losses of substance. As long as the destructive process is in any way active or progressive, so long will the walls of these cavities be lined by the granulation-tissue just alluded to. The contents of the cavities vary greatly according to the duration, and perhaps according also to the nature of the morbid process. In recent cases the contents may be laudable pus, or more usually curdy pus, made up of a thinnish opaque fluid, with flakes of a denser matter. Seldom, indeed, is the contained matter quite homogeneous. In less recent cases the contents may be thick or creamy, or still further inspissated so as to be caseous and firm. In any case there is usually mixed with the matter some bony *débris* that can be felt like grit when the contents of these cavities is passed between the finger and the thumb; and in certain instances this *débris* may appear as actual and visible sequestra.

Lastly, with regard to the extent of the disease in the vertebral column, regarded as a whole, the utmost diversity exists. As already remarked, only one body may be diseased, although, as a rule, many are attacked. The extent to which the individual centra are involved varies greatly. There may be merely a small cavity or excavation in each of the diseased vertebræ, or several of these bodies may be entirely destroyed, and no trace be left of them other than is provided by the undestroyed posterior segments. As a rule, the intervertebral cartilages are more or less extensively diseased, but cases are occasionally met with where extensive loss of several contiguous vertebral bodies is associated with little or no appreciable destruction of the intervening disks. In the place of deep excavations in certain of the bones, there may be found a superficial erosion involving the anterior and lateral surfaces of a number of the bodies, and it is remarkable that when such erosions exist they are seldom limited to a small portion of the column. Some further observations will be made upon this subject in dealing with the deformity that forms so important a feature in the disease.

Before leaving the matter of the osseous changes, it may be well to briefly discuss the *nature of the process* that leads to these changes. It is very gene-

rally allowed that the process is to be classed as a caries, but the great matter in dispute is, whether that caries is simple or tubercular. A vast amount has been written upon this subject, and a good deal of it to very little purpose. Many pathologists have insisted that there is a distinct tuberculosis of the spinal column, while they have at the same time allowed that in many instances the process is non-tubercular. Most elaborate distinctions have been pointed out as serving to distinguish the simple from the tubercular caries: but these distinctions, falling short (as they have until quite recent time) of microscopic demonstration, are for the most part useless and delusive. It has been urged that in the tubercular process the cavities formed are peculiar in their depth, in their walls, and in their contents. The presence of caseous collections has been considered absolute demonstration of tuberculosis, and little opaque specks have been pointed out in the inflamed bone as veritable tubercles. It is now known that tubercles in inflamed bone are bodies not to be criticized by the unaided eye, that the minute opaque specks are but altered inflammatory products, and that caseous matter by no means of necessity indicates a tubercular change. It is well known that tubercular action cannot be judged of merely by the destruction it effects, nor by the outline assumed by the excavations that it leaves. It is also well known that the simple factor of chronicity can so modify the inflammatory process as to lead to a great diversity of appearances.

The question then still remains, Is the pathological process in Pott's disease tubercular or not? If by "tubercle" be meant the "primitive or elementary tubercle" of Köster, the "tubercular follicle" of Charcot, or the "submiliary tubercle" of other authors, and if the presence of this body constitutes a tuberculosis, then is the caries in Pott's disease very often tubercular. In the fleshy granulations of the diseased bone, and in the altered soft parts that lie about it, genuine tubercles have been detected, and Lannelongue has quite recently demonstrated the manner in which the carious action spreads by the development of tubercular tissue.

It may, I think, be considered as distinctly proved that a local tuberculosis takes a part in at least some of the cases of Pott's disease, and, as far as I have been able to see, it probably takes a part in quite the majority of all cases. Unfortunately, a very grave and often most inappropriate clinical meaning has been attributed to local manifestations associated with tubercle. Any individual who presents tubercle in his body, is considered to be possessed with a very fatal ailment, and to be liable to death from the development of some more general and widespread form of tuberculosis. Into the nature of tubercle-producing processes I cannot now enter, but I have endeavored in the book already alluded to, to assign to them a somewhat more simple significance than they are usually credited with. As a matter of fact, the bulk of patients with Pott's disease, even if they do present tubercle in the spinal bones, do not die of general tuberculosis. Indeed, as far as my own experience goes, that form of death is tolerably unusual. Then again the fact must be recognized, that tubercle-producing processes may undergo spontaneous cure, and are, when quite local, susceptible to treatment. This has been fully demonstrated in the matter of scrofulous glands, which often present the most perfect forms of tubercle. I have endeavored elsewhere to show that tubercle is no neoplasm in any other sense than that it is an inflammatory neoplasm, and that it is the outcome of a peculiar and distinctive inflammatory process.

The main features of this inflammatory process are these: it is usually chronic, and is apt to be induced by very slight irritation, and to persist after the irritation that induced it has disappeared. The exudations in such a process are remarkable for their cellular character, and for the large size of

some of their elements. Such exudations show also a remarkable tendency to resist absorption, and to linger in the tissues, the affected area becoming rapidly non-vascular. Among the common products of these inflammations are giant-cells, and, if a certain stage of the process be reached, tubercles. The tendency of the process is to degenerate, not to organize, and the degeneration usually takes the form of caseation. At the same time, these inflammations have a tendency to extend locally and to infect adjacent parts, and their products present certain peculiar properties when inoculated upon animals. Lastly, the great feature of the process is this: it tends to commence in and to most persistently involve lymphatic tissue, and so actively is the marrow or lymph tissue of bone involved in the condition now under notice, that this at first consists essentially in an inflammation of marrow. This account will, I think, very fairly represent the nature of the process in many cases of Pott's malady of the spine. It must, however, be confessed that this condition is not met with in all instances. It is not to be expected in the caries that may follow after injury in a robust person free from any disposition to tubercle-producing inflammations. Such caries will usually be more active in its progress, will show less disposition to indiscriminate spreading, will be surrounded by a barrier of healthier action, and will show a less degenerate condition of its products. On the whole, it will present a more favorable aspect of the disease, but, apart from such marked cases as these, it would be scarcely possible to diagnose the presence of tubercle with any certainty from naked eye appearances only.

(2) *The Changes in the Intervertebral Fibro-cartilages.*—In most cases of Pott's disease, the intervertebral disks share in the destructive change. These bodies become softened and friable, show more or less extensive and often irregular losses of substance, and may be so entirely destroyed as to leave no trace. In cases where many vertebræ are attacked by a superficial erosion, a like erosion is generally to be seen on the front or sides of the corresponding disks, or in the centre of the disk a large cavity filled with more or less fluid matter may be discovered, that may be fairly compared to the cavities formed in the bone. There is generally a disproportion between the amount of destruction in the bones and that in the intervening cartilages. As a rule, the destruction is most marked in the vertebral body, a condition to be explained possibly by the fact that the mischief usually commences in the bone and then spreads to the articular disk. In this way the bone may be found extensively destroyed, and the cartilage thereby laid bare, and marked by a certain amount of softening of its parts, and by some irregular losses of substance. If the bodies of two or three adjacent vertebræ are entirely destroyed, there will be probably no trace of the disks that once intervened between them, although, in some cases, fragments may still be detected among the *débris*, of such an outline as to faintly mark out the position of the lost centra. In exceptional cases the disease would appear to commence in the intervertebral fibro-cartilages, and those bodies may not only present the greater amount of destruction, but may exhibit the sole changes observed in the column. Broca¹ gives the case of a young man, whose spine, after death, showed superficial erosion of all the dorsal vertebræ, with destruction, however, of no less than nine of the intervertebral articulations. In the place of the fibro-cartilages was a whitish, pap-like matter, and some bony *débris*, derived probably from the rubbing together of the bared surfaces of bone. Chassaignac² reported a case, also in an adult, where there was no trace of any intervertebral disks between the second, third, and fourth lumbar vertebræ. The bones appeared sound,

¹ Gaz. Hebdom., p. 298. 1864.

² Gaz. des Hôpitaux, p. 156. 1858.

and were ankylosed together. An abscess had formed, but it was in process of cure.

In an early volume of the Pathological Society's Transactions is an account of a case where the bodies of the six lower dorsal vertebræ were carious on the surface, but where little or no trace of the corresponding disks was to be found.¹ Mr. Adams gives the case of a man, aged 43, who died of lumbar abscess. There was no deformity of the spine. The only lesion found in the column was due to the entire disappearance of the disk between the fourth and fifth lumbar vertebrae. Between these bodies (which are described as a trifle "indurated") a gap existed that was exactly of the size and shape of the lost fibro-cartilage. The same observer records also a like case where the intervertebral cartilages between the tenth and eleventh dorsal and the third and fourth lumbar vertebræ had been entirely destroyed, without any corresponding loss of substance in the adjacent bones. In this instance there was a psoas abscess, but no deformity of the back. Mr. Adams believes that the disease may, from first to last, be limited to the cartilages between the vertebral bodies.²

Before dealing with the process of repair in Pott's disease, it will be necessary to give some account of two very conspicuous results of the process of destruction, viz., the deformity and the abscess.

The Deformity.—When the destructive process has attained a certain magnitude in the anterior segments of the vertebræ, a gap is produced that destroys the continuity of the column, as far, at least, as the part of it in front of the vertebral canal is concerned. It is obvious that the existence of such a gap would be incompatible with any great pressure upon the column, and, if the loss of substance were considerable, it would be scarcely compatible with the erect posture. What usually takes place in Pott's disease, therefore, is this: The column yields at the diseased point, it bends backward, the gap is eliminated by the approximation of the vertebra above the gap with the vertebra below, and in this way an angular projection of the posterior segments of the column is produced. It is needless to say that the development of this deformity is the most conspicuous feature in the disease.

While this falling together of the vertebræ about the seat of the disease is essential to maintain any degree of stability in the column, it at the same time serves probably to keep up and to aggravate the carious action. By this alteration in the configuration of the column, two diseased surfaces are brought in contact, and, more than that, are pressed together, and probably rubbed together. However injurious such approximation of parts may be, it is still very essential for the purpose of repair, and for the subsequent consolidation of the weakened spine. The projection—as above observed—is angular, and the apex of the angle usually corresponds to the posterior segment of that vertebra in whose body the destruction has been the most extensive. There is some relation between the extent of the deformity and the amount of disease, although that relation is by no means a constant one. If only one or two vertebral bodies are lost, but are entirely lost, a sharp angle is produced; but, on the other hand, if many bones are involved, and none of them to any great extent, a more rounded projection results, and a deformity more approaching a curve is produced. If the anterior segments of the column be examined at the seat of the deformity, very various conditions may be met with, depending upon the nature and extent of the destruction. Several vertebræ may be blended together in a confused mass, or two ver-

¹ Trans. Path. Soc., vol. iv. p. 7. London, 1853.

² Ibid., vol. v. p. 241. London, 1854.

tebræ, partly destroyed, may be found so pressed together as to have displaced backwards some fragment of a third and intermediate body more extensively destroyed than themselves. Or the vertebræ, in falling in together to close up the gap, may have included a sequestrum of varying dimensions that lies buried deeply in the angle of the deformity. Or, if the gap involve only the anterior half of the body of a vertebra, the posterior half may be found to have yielded to the superincumbent weight and to the inflammatory softening that invades it, and to have brought about the typical disfigurement by a bending or yielding of its parts.

Further details as to the deformity in this disease will be reserved until the symptoms of the malady come to be considered.

Abscess (Psoas Abscess; Lumbar Abscess; Iliac Abscess, etc.)—An abscess usually presents itself externally at some time in the course of Pott's disease of the spine. There are cases, however, where the malady runs its entire course and ends in ankylosis and cure, and yet no abscess makes its appearance. Such cases are not infrequent, but they cannot be regarded as any evidence of the existence of angular deformity without abscess. Probably in all these cases an abscess has existed at some stage of the disease. This abscess, as the cure has advanced, has itself undergone cure; its contents have become inspissated and caseous, or even calcareous; its walls have become shrunken and inert; and but meagre traces of a once large collection of matter have persisted. I am not aware of any specimen that can of itself offer an undoubted example of spinal caries without abscess, and although the matter may still be regarded as unproven, it is probable that in all instances some suppurative collection is formed. The importance of the abscess in Pott's malady cannot be exaggerated. It usually forms the most troublesome feature in the history of the case, and, more than that, it is directly or indirectly the most common cause of death in those who are afflicted with the disease. I propose to deal first with the mode of formation of the abscess, and secondly with the various forms of the abscess as determined by position, etc.

Formation of the Abscess.—Lannelongue¹ has described this process in considerable detail, and his account agrees in its general points with that most usually given by pathologists. He speaks of the granulations in the bone as penetrating the periosteum, and as spreading the disease in the parts outside that membrane. He speaks of the soft parts around as becoming inflamed and involved in the process, and as presenting granulation-tissue akin to that which has been developed in the bone. Indeed, he urges that the morbid process in the bone and in the soft parts outside it are identical, and are modified only by diversity of structure and opportunities for extension and development.

The *débris* and suppurative matters that result from the caries in the bone are first included, perhaps, within bony walls, and then within walls formed partly by the diseased bone and partly by the inflamed soft parts about it. Lastly, if the purulent collection acquires any magnitude, the wall that bounds it is derived practically from the soft parts alone, and the share taken by the bone in its limits becomes very insignificant. As the disease is in the anterior segments of the column, the abscess appears upon the front surface of the spine, not usually immediately in front—on account of the resistance offered by the anterior common ligament—but a little to one side of the body of the diseased vertebra. The collection will at first be small and sessile. As it increases, it tends to gravitate, and so move downwards on the spine. In this

¹ *Abcès froids et tuberculose osseuse.* Paris, 1881.

way it becomes pedunculated, and its fundus, or most dependent part, acquires dimensions quite out of proportion, often, to the size of its attachment. The abscess when in this condition has been aptly compared by Follin and Duplay to a leech, gorged with blood, hanging on to the column. The direction the purulent collection tends to take—viz., a direction downwards along the front of the column—is to be explained by gravity, by the less resistance offered in this position, and by the decided resistance offered to the progress of the abscess by the structures at the posterior part of the spine. The pathology of such an abscess is identical with the pathology of like abscesses elsewhere. It will be obvious that the abscess will at first occupy the hollow or angle produced by the deformity, and this circumstance will explain the fact that large collections of pus may form in front of the dorsal spine, in this disease, without any injurious pressure been exercised upon the lungs. The contents of the cyst vary. When small, the pus is usually curdy, and contains flaky matters with, possibly, some bony *débris*. When of large size, the matter may still present a curd-like appearance, although more usually it is tolerably thick and homogeneous.

Varieties of the Abscess.—There are cases where the abscess may remain closely adherent to the seat of disease at the spine, and after attaining a certain size may cease to grow. To such collections the name of *vertebral abscess* may be given. It is obvious that they could not be detected during life; that they would indicate but a comparatively slight or non-progressive form of the disease, and that they might afford examples of resolution or spontaneous cure. More usually, however, the abscess increases, and advancing towards the surface ultimately discharges itself from some part of the exterior of the body. Considerable variety is shown in the direction or route whereby these suppurative collections reach the surface, and this variety in routes has led to some variety in names. The situation of the bone-disease will obviously modify to some considerable extent the point at which the abscess will ultimately present itself.

If the disease be in the *cervical* spine, the abscess usually discharges itself at some point about the sides or back of the neck, although it may in rare cases present itself behind the pharynx (post-pharyngeal abscess), or open into the gullet or trachea, or pass down into the thorax, or wander to the anterior part of the neck. If the disease be in the *dorsal* region, the suppuration will usually follow the course of the *psoas* muscle, and thus reach the groin (*psoas abscess*). Or it may incline backwards and discharge itself in the loin (*lumbar abscess*); or it may extend no lower down than the iliac fossa (*iliac abscess*); or it may pass that district and reach the gluteal region, or the perineum (*gluteal abscess*, etc.). Even when all these routes are exhausted, the abscess may still present itself in other and more unusual situations. When the mischief is in the *lumbar* spine, the abscess most commonly points in the lumbar or iliac regions, or may follow the course of the *psoas* muscle, or present itself in one of the less usual situations to be hereafter described.

It will be most convenient to give a very brief description of each of these varieties of abscess depending upon Pott's disease.

Psoas Abscess.—This form of abscess is most usually met with in disease of the lower dorsal or upper lumbar region; but it may occur with spinal caries in any part of the dorso-lumbar portion of the column.

If the abscess commences in the dorsal region, the collection is placed behind the pleura, and gravitates along the front of the *vertebræ* until it reaches the diaphragm. It may pass through the diaphragm, either by creeping along by the side of the aorta, or by making for itself a passage through that partition by inflammatory absorption. Its subsequent course has been

very ably described by Mr. Shaw.¹ "When the abscess," he writes, "has perforated the diaphragm and gained its abdominal side, it comes into relation with the heads of the psoas muscle. That muscle arises by one set of fibres from the sides of the bodies of the vertebræ, by another from the roots of the transverse processes; and stretched across both orifices in front are the ligamenta arcuata. As the abscess, therefore, travels downwards, it has to pass through a narrow strait; it is prevented from enlarging on the forepart by the resistance of the ligamenta arcuata, and at the back by that of the spine and lowest rib; hence, in order to proceed, it has to force its way in the line of the psoas muscle. That, however, can only be done by penetrating into its interior. It accomplishes this, in the first place, by inserting its most advanced part, like a wedge, between the two orifices; it then splits and distends the fibres, so as to form a cavity for the reception of the pus; the muscular fibres become incorporated with the walls of the abscess, and the psoas at length is converted, more or less thoroughly, into an abscess. But the muscle, charged with pus, does not expand equally in every direction. The fascia iliaca forms a kind of sheath for it; and this being particularly strong on the inner side, and united firmly to the brim of the true pelvis, prevents the growth of the abscess inwardly. On the outer side, however, the connections are loose; and there enlargement takes place freely. The abscess now chiefly occupies the hollow between the united fibres of the iliacus internus and psoas muscles on the inside, and the crest of the ilium on the outside. When the advanced part reaches the level of Poupart's ligament, a certain retardation occurs; and then a bulging will be observed along the line of the flexure of the groin. The abscess now perforates the abdominal walls. and the opening is invariably at one place, namely, behind Poupart's ligament, between the united tendons of the iliacus and psoas muscles and the anterior inferior spinous process of the ilium. The situation corresponds to the point of junction of the outer with the middle third of Poupart's ligament." The abscess then descends a certain way down the thigh, and opens usually about the insertion of the psoas.

By this process, the entire psoas muscle may be destroyed and converted into a mere bag of pus, but, no matter how complete the destruction, the branches of the lumbar plexus that traverse the muscle remain intact, and lie, dissected out, across the purulent cavity. This cavity is generally very irregular in its dimensions. Where it passes the diaphragm and the abdominal walls, it is usually narrowed into a small "neck," and there are many cases where the continuity between parts of the abscess-cavity has been destroyed by a temporary or permanent closure of the "neck" situate at the abdominal parietes.

The part of the abscess-cyst just above the perforation in the parietes is usually of considerable dimensions, and like dimensions may also be attained by the abscess in the thigh. On reaching the limb, the pus may leave the psoas, and extend indefinitely about the front of the thigh, forming a large collection of matter, or it may proceed down the limb and point at almost any part of the extremity. Erichsen, indeed, cites a case where an abscess, which took origin in disease of the dorsal vertebræ, opened by the side of the tendo Achillis.²

Sometimes the abscess cavity bifurcates high up, and the pus descends in both psoas muscles, forming a double psoas abscess; and the same condition may be met with where two abscesses form, one on either side, and descend independently towards the pelvis. Pus from disease of the lumbar vertebræ may enter the psoas muscle at any part of its length, and lead to the formation of a definite psoas abscess.

¹ Holmes's System of Surgery, 2d ed., vol. iv. page 119.

² Science and Art of Surgery, 6th ed., vol. ii. 242.

Pus may leave the psoas muscle at almost any point, and lead to abscess in some other situation.

Lumbar Abscess.—This abscess usually has its origin from some disease of the lumbar spine. The pus, guided by the fasciæ of the part, passes along the posterior abdominal wall, in front of the quadratus lumborum muscle, and having reached the edge of that muscle, becomes superficial in the space bounded by the external oblique and latissimus dorsi muscles, the iliac crest, and the last rib; or the pus may pierce the quadratus, or proceed along its inner parts, and ultimately point behind, at the outer edge of the sacro-lumbalis muscle. A lumbar abscess may, however, be but an offshoot from a psoas abscess, or it may proceed from disease in the dorsal spine where the purulent collection has avoided the psoas entirely, and has proceeded direct to the lumbar region. Pus in this region also may avoid the fasciæ, and, escaping into the loose subperitoneal connective tissue, may set up a perinephritic or a pericæcal abscess.

The term *iliac abscess* is applied to a purulent collection in the iliac fossa, and such an abscess may be due to disease in either the lumbar or the dorsal spine. It may be merely an offshoot from a psoas abscess, or a psoas abscess may leave the muscle at the pelvic brim, and, entering the iliac fossa, continue to develop there. In other cases the pus may be directed to the iliac region by the aorta and common and external iliac arteries, or, in the case of lumbar disease, the matter may gravitate directly to this region.

Gluteal abscess is not common, and pus may reach this region in many ways. An iliac abscess may increase considerably, and in time mount up over the crest of the ilium, and so reach the gluteal region. Or pus may be conducted to the great sacro-sciatic notch by the common and internal iliac arteries, and may escape from that notch, either above or below the pyriformis muscle. In other cases, the matter may appear to simply gravitate to the floor of the pelvis and escape at any convenient spot. It may especially follow the great sciatic nerve, and, pursuing the course of that nerve, the abscess may reach as far even as the ham.¹ Lastly, the matter may pass towards the middle line, and may point in the perineum or ischio-rectal fossa.

Some idea of the relative frequency of these abscesses in spinal disease, may be gained from the following table by M. Michel:—²

He gives the following as the result of an examination of 48 cases of Pott's disease accompanied by abscess:—

In 39 of the cases the abscess was about the pelvis. In 6 it was in the neck, and in 3 it was found in the dorsal region.

Of the 39 abscesses about the pelvis—

13 were about the groin,

14 occupied the iliac fossæ and the upper and inner, or outer, part of the corresponding thigh,

1 appeared by the anterior superior spine of the ilium,

7 were in the lumbar region,

3 in the gluteal region, and

1 in the perineum.

Of the 6 about the neck—

1 was in the supra-clavicular fossa.

3 presented at the sides of the neck, and

2 were post-pharyngeal.

The 3 abscesses in the dorsal region appeared near the middle line, and by the sides of the diseased vertebræ.

¹ Follin and Duplay, op. cit., tome iii. p. 666. 1868-9.

² Dict. Encyclop. des Sc. Méd., Art. Rachis. Paris, 1874.

Rare Forms of Spinal Abscess.—(1) In disease of the dorsal spine the pus may proceed more or less directly backwards, and present itself by the sides of the corresponding spinous processes. (2) In disease of the same region the matter may pass forwards beneath the pleura and along the intercostal spaces, and thus reach the anterior mediastinum. Here it may be discharged by the side of the sternum. If the collection occupy the precordial region it may receive pulsations from the heart. (3) Mr. W. Adams has recorded a case that I believe to be unique, where the pus pursued an upward direction. The case was that of a lad, aged 12, with disease of the last two dorsal and upper two lumbar vertebræ. There was angular deformity. The abscess took at once an upward course, and opened opposite the spine of the seventh cervical vertebra. (4) Mr. Shaw¹ has recorded a case where the abscess followed the course of the inguinal canal, and, presenting at the external ring, closely resembled a hernia. He cites, also, a like case recorded by Sir B. Brodie.² (5) Broca³ has recorded a case where a psoas abscess opened into the hip-joint, having effected an entry through the anterior part of the capsule. (6) Leudet⁴ notes an instance of the abscess opening into the spinal canal. (7) Several cases have been put on record where the abscess opened into the lung, and, in some of these instances, fragments of carious bone were expectorated.⁵ In M. Michel's monograph, above alluded to, a case is quoted where the abscess opened both into the lungs and also into the œsophagus. (8) In many instances a collection of pus derived from some spinal mischief may open into the intestinal canal; and usually, if not always, into the colon. There may be an opening into the gut and one also through the skin, so that while pus passes from the rectum, some fecal matter may also escape through the cutaneous aperture. I have seen an example of this condition, and several cases have been recorded. Lallemand⁶ has given the account of a man, aged 19, who developed an abscess in the ischio-rectal fossa. This ultimately became a fistula in ano. When subjected to operation, a number of pieces of necrosed bone were encountered. It was then discovered that the man had "a deformity" of the lumbar spine. It was supposed that in this case the abscess was spinal, and the pieces of bone derived from the vertebræ, but the evidence as to vertebral caries was very scanty, and the body was not examined after death. (9) A spinal abscess may discharge its contents by the urinary bladder; an account of a case presenting this complication is recorded by Shaw.⁷

The matter of implication of the *spinal cord* in Pott's disease will be considered with the "symptoms of the malady."

II. THE PERIOD OF REPAIR.—While destructive changes are going on in the anterior segments of the column, a process of repair is to be observed about the posterior segments. An adhesive form of inflammation appears to be excited about these parts. The periosteum covering the spinous and other processes becomes inflamed, a like change takes place in the ligaments that pass between the various portions of the posterior vertebral segments, and in this change the adjacent connective tissue has also a share. In this way the laminae, and the transverse and spinous processes that correspond to the diseased portion of the spine, become matted together by inflammatory material. As the change advances, the products of the inflammation organize, and the adhesion between the various parts concerned becomes much more intimate and

¹ Loc. cit., p. 123.

³ Bull. de la Soc. Anat., tome xxvi. p. 406.

⁵ See cases by Triquet (ibid., tome xxii. p. 450) and Deville (ibid., tome xxviii. p. 139); also case by Shaw (loc. cit., p. 125).

⁶ Arch. Gén. de Méd., tome vii. p. 474. 1835.

² On Diseases of the Joints, p. 267.

⁴ Ibid., tome xxviii. p. 253.

⁷ Loc. cit., p. 125.

strong. If at this stage the specimen be macerated, the bones in the posterior segment will be found to present here and there irregular bony outgrowths, the result of periostitis, but there will be no direct or indirect bony union between any two adjacent vertebræ. As the process of repair advances, ossification occurs in the fibrous material that has been formed, the periosteal new growths assume a greater magnitude, adjacent vertebræ become locked together by the contact of stalactitic processes, and in certain cases the posterior segments of several of the vertebræ about the seat of disease may be firmly blended by a true ankylosis.

This process of repair in the posterior segments of the column appears early in the course of the malady, and is seldom absent in any but the most severe cases. Evidences of it may be trifling, but they are usually to be noted.

The importance of this process cannot be exaggerated. By the time that the disease has so far advanced in the anterior part of the spine as to destroy, perhaps, several successive bodies, the process in the posterior segments will probably have brought about such consolidation of the column as to prevent that gross bending or breaking of the weakened spine that, without such consolidation, would be almost inevitable.

With regard to the reparative processes in the anterior portions of the column, it must be remembered that the parts lost in Pott's disease are never replaced, and that in no case—after either slight or severe destruction—can the spine ever quite return to its normal condition. If the gap formed by the loss of tissue be considerable, the vertebræ, in falling together to produce the deformity, lessen the dimensions of the cavity and help to expel its contents. Bony surfaces above and below the seat of disease are thus brought together. If the process of cure at once advances, the granulations that cover the exposed bone develop into fibrous tissue, and with this material the cavity in time becomes more or less entirely filled. In certain instances, some portion of the fibrous tissue may ossify, and a more or less complete union of true bone ensue. This true ankylosis, however, is of rare occurrence. If an abscess exists, its contents become more or less absorbed, what was once pus becomes putty-like or caseous matter, the cyst shrinks, its walls become greatly thickened and more fibrous, and by clinging close about the seat of the disease serve to bridge over any gap that may have formed, and to still further strengthen the weakened part. In some cases the absorption of the abscess-contents would appear to be very complete; and in other instances the purulent matter, after becoming caseous, may finally undergo a calcareous metamorphosis. The portion of the column that has experienced loss of substance is strengthened also by a thickening of the periosteum, and by a development of much fibrous tissue in such soft parts as are in the immediate vicinity. By the blending of these altered parts with the remnants of the abscess-wall, a very substantial support may be afforded.

In addition to these means of immobilizing the spine, the gap may be bridged over by stalactitic processes of bone formed by the vertebræ that immediately encroach upon the gap. Sometimes these bridges of bone may serve to fuse the vertebræ together by a true osseous ankylosis, while in other cases they may give support to the part by merely becoming locked together. These masses of new bone are seen most often about the sides of the vertebral bodies, and appear sometimes as if derived from the anterior common ligament.

When the loss of substance is limited to a mere surface-erosion on the bone, the deficiency is supplied by a fibrous formation, although in some very rare cases, Follin and Duplay assert that the excavation may be covered in by a plate of new bone formed from the adjacent sound bone and periosteum.¹

Where the intervertebral disks are alone destroyed, and in some cases where the loss of bone is very limited, the vertebræ on either side of the gap may become fused together by a true, central, bony ankylosis, in addition, possibly, to union by bony processes at their periphery. M. Michel¹ alludes to a case where the fibro-cartilages between all the lower cervical vertebræ had been lost, and where the bodies concerned had become welded together by firm, but irregular, new bone.

If sequestra have formed they may be eliminated, or if they remain *in situ* they will be usually encysted and hidden from view. The tissue that incloses them may be either fibrous or bony, although it more usually belongs to the softer structure. Cloquet² records a case in which the last two dorsal and two upper lumbar vertebræ were necrosed, apparently *en masse*, but in which the entire sequestra were firmly inclosed in a solid, fusiform cyst of bone. By this means the solidity of the spine had been maintained.

Lastly, it must be remembered that the longer the disease has lasted, the less can the vertebral column look to the spinal muscles for support. From long continued disuse these muscles waste, and become degenerate, and by their feebleness add an additional source of weakness to the already debilitated column.

SYMPTOMS OF POTT'S DISEASE.—The symptoms of Pott's disease of the spine vary considerably, both in their comparative frequency and in their intensity. They vary also in the order and time of their appearance, and will obviously be influenced by the locality of the mischief in the column. They can be most conveniently considered under the following distinct heads: (1) Rigidity of the spine. (2) Local pain. (3) The spinal deformity. (4) The abscess. (5) The cord and nerve symptoms. (6) The gait and general aspect. (7) Some general symptoms.

(1) *Rigidity of the Spine.*—A rigidity of that part of the vertebral column which is the seat of the disease is usually the earliest sign of Pott's malady, and is, apart from this fact, a feature of great importance. This rigidity is, when of early occurrence, due to contraction of the muscles of the back, and is nature's mode of endeavoring to keep the inflamed parts at rest. It is exactly to be compared to that rigidity of inflamed joints that is to be especially observed when disease commences in the articular ends of the bones. At a later period of the vertebral disease, this symptom is also due to the permanent rigidity of the posterior segments of the spine, and to those various conditions that lead to a false or true ankylosis of the diseased portion of the column. In advanced cases, where the muscles have become flaccid and atrophied, this latter condition is probably the sole cause of the symptom. To fully appreciate this early evidence of spinal caries, it is well to make one's self familiar with the degree of mobility permitted in the normal column in children and adults of various ages. In examining a young child, it is most convenient to have it placed flat upon its face, and then, on lifting up the lower limbs and moving them (together with the pelvis) in various directions, with the unoccupied hand placed upon the back, any rigidity of the column can be soon estimated. In Pott's malady, the portion of the spine which is the seat of the disease, appears to move in a piece, and will permit of little or no bending or rotation in any direction. In adults this feature can be investigated in the same manner, if an assistant moves the lower limbs and pelvis, and also by making the patient stoop and lean first to the one side and then to the other, or attempt any series of movements that will test the mobility of the spinal column.

¹ Loc. cit., p. 478.

² Gaz. des Hôp., 1858, p. 108.

(2) *Local Pain.*—The symptom of pain, localized at the seat of disease, is of very uncertain occurrence, and is, perhaps, more often absent than present. For diagnostic purposes it is of no value. On this point, Mr. Fisher well observes that “local pain in the back is much more frequently met with when no disease of the spine exists than when the vertebræ are affected.”¹ In many cases no pain is complained of in the back, at the seat of disease, throughout the whole course of the ailment, and in other instances it is scarcely severe enough to draw comment from the patient. This local pain, when present, is usually deep seated, dull, uncertain in its duration, and worse at night and on vigorous movement. It is often much aggravated by any motion that jars the spine, and may be found to be made worse when the spine is per-cussed. Mr. Howard Marsh, speaking of this symptom, says that the pain may be felt either at the affected spot or below it, but very rarely above it.² The pain, when present, is usually most obvious at the earlier stages of the disease, and ceases to be noticed when the spinal column has become more consolidated. It was the custom in less recent times to attach much importance to this local pain, and its recognition was accomplished in doubtful cases by pressing a hot sponge along the spine. This method of investigation has, however, been long proved to be useless. The pain to which reference is now made is due to inflammation of the bones, and proceeds, probably, directly from those tissues. It must be clearly distinguished from the severe, paroxysmal, and often agonizing pain that sometimes radiates from the back, and is due to some nerve-irritation.

In some cases, where the mischief is acute, there may be swelling and heat about the affected part of the spine. Such symptoms, however, are extremely uncommon.

(3) *The Spinal Deformity.*—This deformity, the so-called “angular curvature,” is the most conspicuous symptom in Pott’s disease. The method by which it is produced has been already detailed in the paragraph on the pathology of the disease. In many cases it is the first symptom noticed; and, indeed, in hospital practice it is unusual for a patient to be brought for treatment at a stage of the disease antecedent to the occurrence of the deformity. The deformity makes itself evident at an earlier period in some parts of the spine than it does in others, and the conspicuousness of the “curvature” is greatly influenced by its site.

The deviation of the column is seen earliest when the dorsal region is attacked, the explanation being that the dorsal spine has already a normal curvature backwards. The spinous processes also, in this region, are of great length, and are soon rendered prominent by being separated somewhat from one another. In the lumbar region the deformity is very slow to appear, owing to the fact that the normal curve in this part of the column is directly forwards; and, moreover, there must be considerable destruction of the vertebral bodies before it can make itself evident. In the cervical region no regular deformity is produced. In this region the muscles are better able to support and balance the diseased segments, with the result that, as the destructive process advances, the head simply subsides vertically towards the trunk, and the column becomes shortened. In some cases—either from unequal destruction of the bones, or from unusual muscular action—the cervical spine acquires a slight lateral deviation to one or other side. In any case, the marked rigidity of the column is very conspicuous.

It will thus be seen that the deformity in Pott’s disease will be most conspicuous, and will reach its greatest degree of development, when situate in

¹ Op. cit., p. 12.

² British Medical Journal, vol. i. p. 913. 1881.

the dorsal region. It must not be supposed, however, that an "angular curvature" of necessity appears in all cases of Pott's disease below the cervical region. In some cases—especially in lumbar disease—no deformity appears throughout the whole progress of the malady; but at the same time it must be confessed, that the absence of distortion in dorsal disease is very unusual. Bouvier endeavored to construct a table to show the relative frequency of deformity in the various segments of the spine, with the following results:—¹

Out of 101 instances of Pott's disease there were							
10 cases of lower cervical disease,				3 with deformity,	7 with none.		
55	"	dorsal	"	45	"	10	"
36	"	lumbar	"	20	"	16	"

These statistics are, however, of but slight value, inasmuch as the duration of the disease is not given in the various cases. And it may not be unreasonable to suggest that in some of the cases credited with no deformity, an "angular curvature" may have in time developed.

The deformity itself consists in a bending backwards of the column in the antero-posterior plane of the body, and its great feature is this: it is *angular* and *median*. The extent and prominence of the "curvature" will depend not only upon the seat of the mischief, but upon the amount of bone lost in the anterior segments. A sharp and abrupt angle will usually indicate a severe but limited loss of bony tissue, while a more extensive and more rounded deformity will probably indicate a slight degree of destruction of many vertebræ. In some cases the bending of the column may be so severe that the two parts of the spine form a right angle with one another, or the anterior surface of the vertebra above the excavation may rest on the upper surface of the vertebra below it. When the disease is of long standing, the prominence of the deformity may be increased by the wasting that occurs in the muscles of the back. In certain cases there may be some slight lateral deviation of the spine in addition to the antero-posterior displacement. This condition would appear to be met with only in the lumbar and dorso-lumbar regions, and is due either to unequal destruction of the vertebræ, or to unusual muscular action. In all cases compensatory curves are formed both above and below the seat of the deformity. It is only by means of such compensation that the patient can retain the erect posture. These curves are best seen when the disease is situate in the dorsal spine, and will obviously vary in degree according to the extent of the original deformity. In some cases of Pott's malady involving the lumbar region, where the destruction of the bodies has been sudden and severe, no compensation is possible: the erect posture cannot be maintained, the column falls forwards, and the patient can only progress when upon his hands and feet, or knees.

In nearly all instances the deformity develops slowly, but cases have been recorded in which the "angular curvature" appeared with comparative suddenness. In such cases—of which Michel gives examples—the deformity has usually appeared during some unwonted or forced movement, and has been due to a giving way of some of the supports furnished to the diseased parts, or to fracture of the posterior segments of the column at the seat of caries. Delpech, Nélaton, and Louis all record instances where this sudden formation of the "curve" has been associated with sudden paraplegia. The rapidity with which the deformity develops depends to some extent upon the patient's movements, and upon the non-observance of rest. Shaw,² however, records a case where no increase of the spinal deviation occurred during a period of fourteen years, although the patient was engaged all the while in the work

¹ Quoted by Michel, loc. cit.

² Loc. cit., page 114.

of a blacksmith. At the end of the period mentioned, an abscess appeared. Like examples have been put on record by others. It is important also to note that the deformity may commence and may increase while the horizontal position is being observed. Such cases show that the weight of the column above the seat of disease is by no means the only factor in producing the angular deviation, but that the abdominal muscles may also be active agents in that direction.

(4) *The Abscess.*—The chief points in connection with this symptom have already been dealt with in considering the pathology of the disease; and some further facts will be noted in dealing with the matter of diagnosis. So variable is the evolution of the symptoms of Pott's disease, that the spinal abscess may be the very first evidence of the malady, and, on the other hand, this affection may run its entire course, and end in ankylosis and cure, without any trace of abscess having been observed.

The absence of abscess is, however, quite the exception. As to the period of the disease at which this symptom should become evident, nothing positive can be said. It may appear before any deformity is obvious; it may be the very earliest symptom; it may not appear until the disease has existed for many years. Many cases are recorded where the abscess did not appear for ten, fifteen, twenty, or more years after the commencement of the disease, the patient having in the mean time apparently made a perfect recovery. It is probable that all such cases are examples of what Sir James Paget¹ has called "residual abscess," that is to say, an abscess taking its origin from the residues or relicts of past suppuration. The patient has caries of certain vertebræ, and an abscess is formed at the seat of disease, but does not tend to reach the surface of the body. In time a process of cure takes place, the wall of the abscess shrinks, its contents become more or less absorbed, and perhaps no trace is left but some small collection of caseous matter. As long as the patient's health remains good, and as long as no injury or unusual circumstance tends to irritate the part, so long does this residuum of a past inflammation remain inert. But when these untoward conditions are provided, the ill-disposed material acts as an injurious foreign body, and an abscess that perhaps reaches the surface is the result.

As to the influence of local and general conditions upon the formation of the abscess, something a little more definite can be said. As may be surmised, the more acute and rapid is the spinal mischief, the more certain and the earlier is an abscess likely to appear. Moreover, a general condition of ill-health is apt to affect the formation of the abscess in a like injurious manner. The same may be said of neglect of treatment, of persistence in movement and exercise, and of direct injury to the diseased parts. In opposition to these general statements, however, numerous exceptions have been recorded. Mr. Fisher mentions the case of a gentleman who had presented a projection of the spine for more than two years, no abscess appearing until the end of that period, although the patient had during the whole time indulged in the usual athletic pursuits of young men. Then again, an abscess may be associated with a form of Pott's disease that has assumed a very chronic course, has given little or no trouble, and has led to but trifling deformity. On the other hand, instances are recorded of an absence of external abscess, though the disease is accompanied with severe deformity and paraplegia.

The general features of the abscesses that accompany Pott's malady are identical with those of cold abscess in general, and require no especial description. Lannelongue² has shown that the surface-temperature over these col-

¹ Clinical Lectures and Essays. London, 1877.

² Loc. cit., page 171.

lections is higher than that of the corresponding surface on the other side of the body. He quotes the case of a child, aged $7\frac{1}{2}$ years, with a lumbar deformity and a large psoas abscess at the upper part of the left thigh. This abscess showed an absolute absence of any of the common signs of inflammation, and was indeed a typical cold abscess, yet the temperature noted was as follows:—

	On one occasion.	On another occasion.
Temperature in axilla,	37°·6 (99°·7 F.)	37°·5 (99°·5 F.)
Surface temperature of thigh on healthy side,	37°·0 (98°·6 F.)	36°·5 (97°·7 F.)
Surface temperature of thigh over abscess,	37°·2 (99°·0 F.)	37°·1 (98°·8 F.)

Lannelongue has also shown that this feature in the temperature applies to all cold abscesses.

(5) *The Symptoms depending upon Implication of the Spinal Cord and Spinal Nerves.*—Considering, on the one hand, the position of the spinal cord and nerves, and, on the other, the great deformity in the column and the great destruction of parts often produced by Pott's disease, it is no matter of wonder that these delicate nerve-structures sometimes suffer injury. They are, however, by no means constantly involved. The frequent immunity of the cord in Pott's malady is, to some extent, to be explained by the fact that the cord occupies the posterior portion of the vertebral column, a part not only as a rule exempt from destructive disease, but the seat actually of extensive reparative changes. It also must be borne in mind that the changes in the column are of such a nature as to cause the inflammatory products to take a forward direction, while the development of the deformity is usually so slow that the cord has time, as it were, to accommodate itself to the change. And it is marvellous to what changes the cord will accommodate itself, if only the morbid influences around it are slow in their action. In any case of Pott's disease with severe deformity, the cord must not only be abruptly bent, and compelled, possibly, to occupy a much more limited space than in the normal condition, but it would appear that in some instances it must be actually shortened. Still, it is common to have examples of severe spinal deformity without nervous symptoms of any kind.

Roughly speaking, the symptoms that are now to be detailed may be ascribed either to irritation of the spinal cord and nerves, or to such an injury to those parts as may cause temporary or permanent interruption of their functions. Thus, there may be, on the one hand, severe pain or hyperæsthesia, and on the other, loss of sensation. And as regards the motor tracts, there may be muscular spasms and increased reflex action in one instance, and absolute paralysis of certain parts in another.

The post-mortem examination of patients with Pott's disease, who have exhibited nerve-symptoms during life, will give very various results. In some cases, the meninges of the cord will be found much thickened at the seat of disease, or, in other instances, a considerable inflammatory exudation will exist between those membranes and the spinal wall, and intimate adhesions may be found between those parts. As regards the cord itself, it may be congested, or inflamed, or the seat of a definite sclerosis. In many cases it will show some limited softening, that, while of very varying extent, will be found most usually to involve the motor regions of the cord. Injurious pressure will be found in most instances to be the cause of these conditions, and especially of the condition of softening in the medulla spinalis. The pressure may be effected by the abrupt bending of the spine, or be caused by detached vertebræ, or displaced fragments of bone; or it may be due to the bulging of inflammatory products toward the spinal canal, or to the undue prominence in the same direction of new bone formations. As regards the

spinal nerves, they are liable to become inflamed on account of their proximity to the seat of disease. They are liable to irritation from the near presence of fragments of bone, or displaced portions of the column. They are susceptible, also, to varying degrees of injury from pressure. When many vertebræ are lost, the corresponding intervertebral foramina are usually more or less involved, and in such instances Michel observes that it is common for many successive spinal nerves to issue from one huge and irregular intervertebral foramen produced by the disease.

It is extremely difficult to say in what cases cord and nerve symptoms are to be expected, and in what cases they are not apt to occur. They may appear early in quite slight cases, or they may be entirely absent in the most severe examples of the disease.

As to the relation between the cord-symptoms and the local condition in the vertebral column, these few points can alone be mentioned: Cord-symptoms are more apt to occur in cases where the disease progresses rapidly, and the deformity is sooner produced than in cases where the opposite conditions obtain. Cord-symptoms are more apt to occur in cases associated with deformity than in those unattended with deviation of the column. According to Bouvier's statistics on this point, out of 64 cases of Pott's disease with deformity, paralysis occurred in 33 instances; whereas only 8 examples of paralysis were met with in 32 cases of the disease unassociated with deformity. Allowing for many exceptions, cord-symptoms are more apt to occur in severe forms of the disease, in cases associated with much muscular weakness, in cases where undue movement has been allowed or no treatment adopted, and in cases where accident has suddenly added to the extent of the deformity.

The various symptoms may most conveniently be considered under two heads—first, disturbances of sensation, and secondly, disturbances of the motor system.

Disturbances of Sensation.—Pain transmitted along a certain nerve or nerves is very often the first symptom of disturbance of the great nerve-structures. This pain is probably due to irritation of some of the spinal nerves as they issue from the intervertebral foramina, although it may in some cases be due to a disturbance in the medulla spinalis itself. The seat of the pain varies—as Mr. Howard Marsh has well pointed out—with the locality of the bone-mischief. In caries of the lower cervical region, the pain is apt to radiate over the shoulders and down the arms, or over the upper part of the front of the chest. In dorsal disease, the pain follows the intercostal nerves, and may be felt at the sides, or in front of the trunk, about the middle line. When the malady attacks the lumbar spine, the pain tends to radiate about the loins and pelvis, or to run down the limbs and to extend even to the feet.¹ The characters of this pain are tolerably distinctive. It is sometimes severe, usually sharp and paroxysmal, rather than continuous. It is indeed a neuralgic pain.

It is often limited to one side of the body, or even to one nerve. For example, in cases of dorsal disease, intercostal neuralgia of a single space is by no means uncommon. The pain may be associated with hyperæsthesia of the part supplied by the affected nerve, or of a part supplied by some adjacent trunk. But such a complication is not common. The pain is very usually made worse by exercise and violent movement, and a sudden jarring of the column may render it, for the moment, almost agonizing; on the other hand, the patient is easier when in the recumbent posture, and often the painful sensation will entirely disappear when a little extension is applied to the column.

¹ The Diagnosis of Caries of the Spine in the Stage preceding Angular Curvature. British Medical Journal, vol. i. page 913. 1881.

This "nerve-pain" is very different from the dull, deep-seated, and well-localized pain already spoken of in a previous paragraph. The latter is a "bone-pain," is worse at night, is perhaps modified by the weather, and, if increased on movement, is increased to no severe extent. The one depends upon the irritation of a nerve-trunk, the other upon actual disease in the bone, augmented by the mutual pressure of the parts.

In some instances, the patient may complain of a painful sensation about the body, as of a cord tied around it, about the level of the epigastrium or umbilicus. This sensation may be an extremely painful one, and may, according to some French authors, be very like the pain of a linear burn. The symptom, although common in many affections of the cord, is certainly extremely rare in Pott's disease, as Mr. Marsh has recently pointed out. The same writer has also drawn attention to the fact that the pain when located about the abdomen, may be readily the cause of a faulty diagnosis. He records the case of a child, aged five, who suffered from a pain in the stomach supposed to be due to indigestion, for which, indeed, she was treated for some weeks. The pain was in reality due to disease in the mid-dorsal vertebrae, and could have been distinguished from the pain of indigestion by the fact that it was not worse after meals, that it was increased by vigorous movement, and relieved by recumbency. The "lightning" pains that are so common in certain diseases of the cord are not met with in Pott's malady, although tingling sensations may be felt in parts, or a discomfort described as "prickling pains."

Lastly, there may be a loss of sensation in parts below the seat of the vertebral disease. This anæsthesia is quite uncommon, and never occurs alone, but when present is always associated with loss of motion, which, in nearly every instance, will be found to have preceded it, and to be of a more extensive character. It is rare for the loss of sensation to be absolute. Usually there is only a sense of numbness, or an anæsthesia of a comparatively limited district. The instances of complete loss of all sensation below the seat of disease are very few, and have in all examples been associated with absolute paraplegia.

Disturbances of the Motor Nervous System.—These disturbances may be classed under two heads: (a) Those marked by nerve-irritation, convulsions, spasms, etc.; (b) those marked by loss of nerve-function, or palsies.

(a) These disturbances may assume a variety of aspects. In the least marked instances, there may be simply undue reflex irritability. In such cases, on touching or gently tickling the sole of the foot, the limb is violently drawn up, or movements may be induced in it by equally trifling irritation. In other cases this morbid condition of the nerve-centre may express itself in an involuntary jactitation of the limbs, that may be brought about by very slight peripheral disturbances.

In severe grades of this condition, the limbs below the seat of the vertebral disease may exhibit spasmodic or convulsive movements. These spasms may sometimes be very violent, and associated with considerable pain. They may occur spontaneously, but can be induced or rendered more vigorous by irritating the periphery, as by tickling the feet or pinching the skin, etc. These symptoms are practically limited to the muscles of the lower limbs, and to the abdominal and sacro-lumbar muscles. Only one limb may be affected, or only one muscle or set of muscles in that limb, and when both sides of the body exhibit these spasmodic attacks, the symptoms are usually more marked on one side than on the other.

In other instances the spasm may be continuous, and the legs may remain rigidly drawn up. This form of contraction may be associated with much pain, may be of limited or unequal extent, and may alternate or be associated

with the intermittent or clonic spasm just referred to. The condition is generally known as "spastic contraction," and is perhaps somewhat more frequent than is the condition marked by interrupted spasm. So rigid may the patient's body become in some cases where the muscles of the lower limb and back are the seat of continuous muscular contraction, that, according to Shaw, he may be turned over in bed like a log.

Among the peculiar phases of motor-nerve disturbance in Pott's disease may be mentioned torticollis, observed in some cases of caries of the cervical spine, and also a severe and intermittent form of dyspnoea, occasionally met with in caries of the same situation, and due, according to Michel, to irritation, or perhaps paralysis, of the phrenic nerve.

(b) *Palsies*.—The usual form of motor paralysis observed in angular deformity is paraplegia. This may be complete, and equally marked in the two lower limbs. It usually develops slowly, although cases are recorded of sudden paraplegia in connection with the sudden appearance of the spinal deformity. The loss of motor power may be more marked in one extremity than in another, or may be limited, more or less, to one particular set of muscles. In other instances there may be mere feebleness in the part, which feebleness may, like the more complete losses of power, be of limited or unequal extent. It is probable that many of the cases of marked paralysis of a limited set of muscles are due to pressure upon the spinal nerves rather than to an injury to the cord itself. With reference to the previous symptoms, the order adopted in their development is usually as follows: First, involuntary jactitation of the limbs, then constant muscular spasm, and, lastly, paralysis. Often, however, the loss of power is preceded by no evidences of spasm. The paraplegia in Pott's malady has certain peculiarities. It is very usually unassociated with any loss of sensation, or allied with but trifling disturbances of that function. It is, moreover, very seldom accompanied by loss of control over the bladder or rectum, and when such a complication is present, it is usually but slightly marked, and often preceded by a painful tenesmus. In incomplete palsies the muscular sense remains unimpaired. On account of the comparative rarity of defects in sensation, bed-sores are as unusual in Pott's disease as they are common in other forms of paraplegia. Lastly, this form of loss of power may be entirely recovered from, as will be mentioned when the matter of prognosis is discussed. The reaction of the paralyzed muscles to electricity remains normal, unless the condition is of such long standing that the muscular tissue has become disorganized.

The convulsive movements already referred to may sometimes be observed in the paralyzed limbs, and when present constitute a very distinctive feature. They can only occur in cases that are comparatively recent, and will obviously not be possible when the muscular structure has become much changed from prolonged disease.

(6) *The Gait and General Aspect*.—In marked cases of the disease, the patient in walking keeps the spine peculiarly rigid. He walks with his legs only, often shuffling the feet along, and swaying the body to and fro. His movements, therefore, are stiff and ungraceful. When asked to pick up an object from the ground, instead of bending the back, he bends the lower limbs, and approaches the object sideways, as it were. This attitude is well shown in drawings in Prof. Agnew's article on Surgical Diagnosis.¹

In cases where the deformity is marked, the patient stands with the head thrown back, and often supports himself by resting his hands upon the thighs. If one side of the column be more affected than the other, the

¹ See Vol. I., page 348, Figs. 21 and 22.

patient is disposed to lean the body towards the less affected side. When in the recumbent posture, the patient prefers to lie upon his side, and when moving from that position to the sitting posture, he effects the movement by turning over on to his belly, and then raises himself by his hands and knees. As a consequence of the angular deviation of the column, the whole trunk appears shortened and out of proportion to the extremities. The antero-posterior diameter is increased, and the sternum protrudes. In severe disease of the dorsal spine this protrusion of the sternum may be considerable. The ribs are often rendered more or less rigid, not only by the constrained position induced by the spinal and thoracic deformity, but often also by destruction or ankylosis of the costo-vertebral joints. Lastly, the shoulders appear to be raised, and the head and neck to be more or less sunken towards the thorax. One feature that has been particularly alluded to by Sayre, is the short, "grunting" respiration often observed in cases of dorsal disease with much deformity both of chest and spine. Dr. Sayre asserts that this symptom is often immediately relieved when the patient is suspended.

(7) *General Symptoms.*—Of the general symptoms that may accompany Pott's disease, little need be said. The patient may or may not present evidence of struma, or be afflicted with any concomitant scrofulous disease. Seldom will the subject of the malady present the appearance of actual good health. When external discharge of matter is accomplished, there will probably be a rise of temperature, some wasting, and increasing debility, with all the familiar symptoms of hectic fever. If the suppuration be of long standing, symptoms may arise that point to amyloid or fatty degeneration of the viscera. At any time there may be certain visceral complications of a less chronic character, more or less directly connected with the seat of the disease. With regard, indeed, to any general symptoms that have not been mentioned, they may be said to be such only as are incidental to all conditions of feeble health, and to all states of extensive and continued suppuration.

DIAGNOSIS OF POTT'S DISEASE.—The main points upon which the diagnosis of Pott's disease is to be based, have been exposed in the preceding pages. It remains, however, to discuss the differential diagnosis, and to set forth the means whereby this malady may be distinguished from such diseases as, in certain features, may have resemblance to it. The matter can be best considered under the three heads: The spinal deformity; the cord and nerve symptoms; the abscess.

(1) *The Spinal Deformity.*—The great features of the spinal deviation in Pott's disease are its angularity, its median position, and its general rigidity.

In *cyphosis* there is a bending backwards of the spine, but in this condition the deformity assumes the outline of a curve that usually involves in an equal degree a large portion of the column. There is in the first instance no rigidity, and, except in cases of spondylitis deformans, at no time absolute or complete rigidity.

Cases of Pott's disease, where a deformity exists associated with some lateral deviation of the column, but, at the same time, with an absence of any more familiar evidences of the malady, may possibly be mistaken for *lateral curvature*. Shaw gives an instance in illustration of this. He says that he "was consulted about a girl, aged fifteen, who had a projection at the dorso-lumbar region, with a distinctly marked deviation of the spine to one side, simulating closely lateral curvature. The medical attendant had considered the case to be of that kind, and had put the patient on a course of calisthenic exercises. It was distinctly ascertained, however, that the prominence was the effect of caries; and the principal diagnostic sign was the directness

with which the spinous processes stood out backwardly against the skin; for it is a never-failing observation in regard to lateral distortion, that, owing to the rotation of the column on its long axis, which always accompanies incurvation, the spinous processes are pointed laterally, towards the concavity; and that to such a degree that they are nearly hidden from view by the overlapping of the edge of the longissimus dorsi."¹

Aneurisms of the abdominal and thoracic aorta may cause such an erosion of the spine as to lead to the angular deformity of Pott's disease. If the destruction of bone be still more extensive, nerve-symptoms are produced from pressure, that may have the characters of those met with in caries, and that may go on even to paraplegia.² In such cases the distinctive symptoms of aneurism would be present, and the diagnosis patent. At the same time, it must be noted that these aneurisms occur usually at a time of life when spinal caries is very rarely met with.

Michel refers to a case recorded by Mazet, where during life there was an "angular curvature" of the column, and near it a large fluctuating tumor like a chronic abscess. It, however, proved to be a *hydatid cyst* growing from the vertebral canal.

(2) *The Cord and Nerve Symptoms.*—In cases where the characteristic deformity exists, there can be no difficulty in diagnosing these symptoms; or in any case at least where such symptoms coexisted with "angular curve," it would be safe to ascribe the former to the same disease that had caused the latter.

The most difficult cases of Pott's malady to recognize are those associated with no deformity. In some such cases, a psoas or lumbar abscess may exist and assist the diagnosis, but when that symptom is absent, an opinion has to be based to a great extent upon such nervous disturbances as may be present. In these cases, without deformity, the spine will be found to be more or less rigid in one part; there may be local pain, increased on exercise and relieved by extension; and there may be some peculiarity in the patient's gait and movements. If any symptoms of nerve or cord disturbance exist, they may be of great value, and it is now necessary to point out with what other conditions those symptoms may be confused. In "*hysteria of the spine*," the patient may complain of severe pain about some part of the column, of inability to move the back or to maintain the erect posture without great suffering, and possibly of radiating pains along certain nerves, such as the intercostal. The pain may be localized about the vertebra prominens, and the normal projection of this vertebra may lay the foundation for the assertion that the "spine is growing out." If the patient has taken to her bed—as is not infrequently the case—under the impression that she has severe spinal mischief, the spinous processes of many vertebræ may in time appear unduly prominent, from atrophy of the muscles from disuse. If the case be associated with "hysterical paraplegia," a fresh complication is introduced. In these examples of simulated disease, however, there will generally be distinct evidences of hysteria, an absence of any real angular deformity, and no rigidity of the affected part. The pain, moreover, will be of that limited and agonizing character common in hysterical neuralgia. Lastly, when the spine is being examined, the patient will probably wince and jerk the back away every time that the column is touched, a manœuvre that would certainly not be executed if the tenderness depended upon caries.

In cases of *muscular rheumatism* of the back, there may be much local pain and a good deal of rigidity of the part. Such cases, however, may be distin-

¹ Loc. cit., page 111.

² Quincke, Diseases of Arteries; Ziemssen's Cyclopædia of Medicine, vol. vi. p. 434.

guished from those of Pott's disease by the following features. The rheumatic pain is diffused, and follows no particular nerve; the pain is increased rather than relieved by extension; the parts are tender often over a wide area; and the disease is more common at an age when Pott's disease is rare. There will, probably, be in addition a history of rheumatic affections.

Cases of commencing *hip-disease* in children have been mistaken for an early stage of Pott's malady. Children so afflicted often cry if moved much; keep the spine, pelvis, and hip-joints as rigid as possible; are disinclined for any exercise; and often complain of vague pains that may not be very accurately localized. A little care in the examination of doubtful cases, however, will soon eliminate the instances of hip-mischief. *Infantile paralysis* may in some way imitate the paraplegia of Pott's disease, from which it can, however, be distinguished by the history of the case, the atrophy of the affected muscles, and the absence of any rigidity or any pain about the spine. Follin and Duplay assert that muscular weakness associated with *rickets* may resemble the loss of power sometimes met with in Pott's malady, but it is difficult to appreciate the grounds of such resemblance, or to imagine that it could be so close as to cause confusion in diagnosis. One author reaches the extreme limit of doubtful refinement in diagnosis, when he points out how Pott's malady without deformity is to be distinguished from *chronic nephritis*.

(3) *The Abscess*.—The differential diagnosis of abscess from spinal disease appearing in various regions, can only be given in the merest outline.

Abscesses in the lumbar or iliac regions must be distinguished from simple chronic abscesses, from perinephritic and pericæcal abscesses, from abscesses due to disease of the ilium, and from certain fluctuating renal tumors. In the *simple chronic abscess*, the symptoms will be purely negative. In the *perinephritic and pericæcal abscesses*, there will probably be evidence of some disturbance of the viscera about which the pus has formed, and an absence of all the local signs of Pott's disease. The latter abscess is met with only on the right side of the body, and the pus it discharges is usually of feculent odor. It must also be remembered that pus from spinal caries may occupy the connective tissue about the kidney or cæcum. *Caries or necrosis of the ilium* can in the early stages be little more than suspected, and the symptoms of abscess will advance without any evidence of Pott's malady appearing. The *fluctuating renal tumor* may be hydatid, cystic, or cancerous, or due to distension of the kidney with urine or pus.

With regard to the inguinal region, it is here that the typical psoas abscess is met with. In this abscess there will be a smooth, round, fluctuating swelling below the groin, and about the site of the ilio-psoas insertion. There will probably be a second collection to be felt in the iliac region above the groin. The collection in the thigh can be more or less reduced on pressure, and will present a distinct impulse on coughing or on tapping the iliac tumor. In some instances the communication between the iliac and inguinal collections may be for a time cut off, when the lower tumor will present simply the features of a chronic abscess. Psoas abscess in the groin may be mistaken for abscess from *hip-disease*, but in the latter instance there will be more or less rigidity of the joint in a flexed and adducted posture, with tilting up of the pelvis on the diseased side. The spine will be in a condition of lordosis, and often unduly mobile. There will be no impulse at the collection on coughing, and the other evidences of hip-mischief will probably be present. Cases are recorded where the spinal abscess has been mistaken for a *femoral hernia*. Shaw gives an excellent example of such a case where a truss was actually ordered. The psoas abscess is, however, nearly always to the outer side of the femoral vessels, and, on examination, the femoral canal will be found to

be clear. The hernia, if reducible, is returned with a peculiar gurgle, and is of slow formation. If of any size, it will also be, as a rule, tympanitic on percussion. The following case—recorded by Shaw¹—will show how closely a *cancerous tumor* about the groin may imitate a spinal abscess. He had under his care “a female, of middle age, who had lateral curvature of the spine from girlhood; and in whom the hump was so prominent and abrupt, that it might be mistaken for angular deformity from caries of the vertebræ. She was admitted for a tumor that occupied the inner side of the left wing of the pelvis, and was on a level, at its anterior part, with the crest of the ilium. An oval-shaped, projecting lobe, in course of time formed on its most dependent face, near Poupart's ligament; and the feeling communicated to the finger, when examining that part, bore the greatest resemblance to what is conveyed by pus, when near the surface of an abscess. The subsequent progress and termination of the case showed that the tumor was one of medullary cancer.” Among *other tumors* in the inguinal region that may possibly be confused with spinal abscess, are bubo; varix of the saphenous vein; fatty, cystic, and other soft or fluctuating tumors; and possibly some cases of aneurism.

Before concluding the matter of diagnosis, it is to be observed that it is scarcely possible to diagnose with any certainty the *nature* of the bone-mischief during life. In less recent times, much was written on the distinctions between simple and tubercular caries, and on this point the arrangement of Broca was perhaps the most popular. He asserted that tubercular osteitis occurred in children, and, as a rule, in the cervical and dorsal regions, and that it soon led to deformity, and to paraplegia. Whereas simple caries appeared usually in adults, and in the lumbar spine, and was marked by a very tardy deformity and no paralytic symptoms. This arrangement is very fascinating, but must, in the present state of our knowledge, be, I think, discarded as useless.

PROGRESS, PROGNOSIS, ETC.—The *progress* of the disease is, as a rule, slow. In some cases it may be so slow, and produce so few symptoms, that the malady is hardly noticed by the patient. Thus cases are recorded where the patient followed a laborious employment during the development of the disease, and where years elapsed before any troublesome symptoms—such as abscess or cord-troubles—appeared. There are cases, on the contrary, where the malady has been acute, and has pursued a rapid course. But, as a rule, even these acute cases are not acute from the first. They begin as chronic maladies, and then, for some particular reason, take on an acute action. The great feature, however, in the progress of Pott's disease is its uncertainty. Seldom is its progress uniform, but marked rather by the utmost variety, not only in the rate at which it advances, but also in the period at which certain symptoms appear, and in the general features of those symptoms themselves. The actual time, therefore, occupied by the disease must vary considerably. Except in very few instances, it can hardly run its course in less than six or nine months, although Michel asserts that the period of time from the commencement to the termination of the malady may be as little as three months. In the majority of cases, the duration of the active disease is to be estimated by years, and not by months, and perhaps one or two years would be an average time for the period occupied by the course of the disease. It would be difficult, perhaps impossible, to detail the circumstances that influence the rate of progress of spinal caries. It may be, here, only necessary to observe that the malady, as a rule, advances more rapidly in

¹ Loc. cit., page 126.

adults than it does in children, and in the cachectic and ill-nourished than in those originally robust. It must be understood that the disease is considered to end when ankylosis has ensued, and at any time, of course, the period of the disease may be terminated by death. In cases of cure, the deformity still persists, and patients may live a lifetime with all the outward signs of Pott's malady, and yet enjoy good, or at least fair, health.

The *prognosis* with regard to the *deformity* is therefore very distinct. The lost parts of the vertebral column are never restored, and the deformity never disappears. With regard to the *abscess*, perfect cure may be brought about without the appearance of any purulent collection; or the pus may remain stationary for an indefinite time, and then either entirely disappear or discharge itself from the surface. The usual course, however, is for an abscess to form that comes in time to the surface, and then discharges itself, and this particularly applies to cases of Pott's disease in adults. When the abscess has opened, and has discharged for a considerable period, cure may still follow; the sinuses may close, the discharge cease, and the spine consolidate. This fortunate result would appear to be most usual when the abscess opens close to the seat of the disease. Michel¹ has collected 22 examples of cure following upon the natural or artificial evacuation of the abscess. Of these abscesses 8 were psoas, 1 appeared at the sciatic notch, 1 in the perineum, and 12 in the dorso-lumbar region. As already observed, a residual abscess may appear at almost any time, and in any case of Pott's malady that has undergone cure, or what is practically a cure.

The *paraplegia* in Pott's malady may persist, but at the same time it is not infrequently recovered from. The recovery may be complete and permanent, or it may be only partial, and a certain set or sets of muscles may remain absolutely paralyzed, or the patient may always present some feebleness in the whole series of muscles that have been affected. Cases of recovery are recorded in quite severe examples of paraplegia. Thus Dr. Sowers reports an instance in a little girl aged $8\frac{1}{2}$ years, whose lower limbs were entirely paralyzed, and who in addition had some loss of power in both upper extremities, and also in the bladder. She made a complete recovery. As may be supposed, the prognosis is much more favorable in children than in adults. More than one attack of paralysis may be recovered from. Thus Shaw quotes the case of a boy, aged six, who had two attacks of paraplegia in two years. He recovered perfectly from both attacks. Nichols gives an account of a man, aged 24, who had three attacks of paraplegia in eight years.

It remains now to consider the prospects of *cure* in any case, and the causes of *death*. A cure is much more common in children than in adults, and in those cases associated with deformity than in those without. The following statistics given by Michel bear upon this point. In 33 fatal cases without deformity, 24 died of the disease itself, and 9 of some other disorder. In 68 fatal cases with deformity, 35 died of the disease itself, and 33 from some other cause.

The extent of the disease has also to be considered, and the general state of the patient's health. The presence of abscess or of paraplegia will very materially lessen the prospects of cure; and paralysis in connection with cervical disease is peculiarly apt to end in death.

When death ensues, it is most commonly from the abscess. The patient dies of hectic, or of amyloid degeneration of the viscera, or of pyæmia, or of simple asthenia—worn out by excessive discharge—or indeed by any of those modes of death that result from long-continued suppuration. Very often a sudden change for the worse occurs in the patient's condition when

¹ Loc. cit., p. 493.

the abscess is opened, and out of 28 cases reported by Michel, where the time of the evacuation of the abscess was known, death followed in 20 days in 10 instances. The same author also gives the following as the causes of death in 44 cases of spinal abscess.

In 14 cases	death	resulted	from	tuberculosis	of the lungs.
In 16	"	"	"	"	marasmus.
In 5	"	"	"	"	sloughing of the limbs from œdema.
In 4	"	"	"	"	pyæmia.
In 2	"	"	"	"	arachnitis.
In 2	"	"	"	"	pus in the medullary canal.
In 1	"	"	"	"	pneumonia.

In some cases the patient dies from extension of the mischief in the cord, or from actual inflammation of the cord or its membranes.

Any thoracic complication is apt to be dangerous in those cases of Pott's disease which are associated with deformed chest.

Among the less usual causes of death, may be mentioned hemorrhage, as in a case observed by Legouest,¹ where fatal bleeding occurred from the vertebral artery in an instance of cervical caries, and as in another case recorded by Fuller,² where the abdominal aorta was perforated. [The editor³ has recorded a case of psoas abscess which ended fatally through hemorrhage from a branch of the internal iliac artery.] Death has also occurred from suffocation due to the sudden discharge of a spinal abscess into the bronchi, and from like unusual causes.

TREATMENT OF POTT'S DISEASE.—This may be considered under the heads of local and general treatment.

Local Treatment.—The treatment of the spine in Pott's disease has been for a considerable period a subject of dispute, and is still a matter upon which much difference of opinion exists. These differences involve, however, rather matters of detail than general principles, and it is more than probable that they will become still less conspicuous when our knowledge of the pathology of the disease is more distinct. The indications for local treatment are well expressed by Mr. Fisher, in his essay on this deformity. They are: "First, the obtaining a condition of immobility for the diseased bones; secondly, the relieving them from the pressure caused by the weight of the body above; thirdly, the relaxation of local muscular contraction; and, lastly, the restoring of the spine, as far as possible, to its normal condition."⁴ With regard to this last indication, the term "normal" must be used in a very modified sense. A consolidation of the diseased part is the issue hoped for, and a rigidity of the region is desired, that obtains in no normal spine. Moreover, the removal of the deformity must always be a secondary consideration in treatment. Deformity of some amount is necessary for substantial cure, and no method of treatment can be more injurious than that proposed for the sole purpose of removing the disfigurement. Local treatment with this object is the usual expedient of the "bone-setter" who treats Pott's disease. He professes to recognize in the deformity a dislocation of the spine, and proceeds to restore the parts by violent extension, and by manipulation of a no more gentle character. Under such measures the posterior segments of the column, upon which the main hope of cure depends, have been broken across, and sudden paraplegia, or even death, has been the result. The indications just mentioned may be

¹ Gazette Hebdom., p. 76. 1861.

² Ibid., p. 524. 1859.

³ Principles and Practice of Surgery, 3d ed., p. 662, Philadelphia, 1882.

⁴ Op. cit., p. 18.

carried out by (1) the recumbent posture; (2) certain mechanical appliances; (3) a rigid jacket applied during extension of the column.

(1) Treatment by *prolonged recumbency* is of extreme value in Pott's disease. Indeed, considered in the abstract, or apart from certain difficulties and inconveniences, it is probably the very best treatment available for this malady. In the recumbent posture the spine is at rest, and the muscles relaxed, the evils of the pressure of the diseased surfaces against one another are minimized or removed, and the very least inducements are offered for the malady to progress. In all rapid and acute cases, this plan of treatment should be strictly carried out, and should be the only means adopted. In other cases it is well, under all circumstances, to commence the treatment by a period of enforced recumbency, and to allow this measure to be a preliminary to further treatment by instruments, jackets, etc. Many surgeons would, however, urge that recumbency should be the treatment of all forms of Pott's malady, and should constitute the only local measure. Without going as far as this, it must be regretted that this simple expedient is not more extensively and practically resorted to, and that more means are not afforded in hospitals for its employment. When this mode of treatment is adopted, the patient should be made to lie upon a firm, well-padded mattress, with the spine as straight as possible, and with the head, trunk, and limbs on the same plane. Any but slight and necessary movements must be forbidden, and the more recent and acute the case, the more essential is it that absolute rest shall be enjoined. To effect this end in the case of children, Mr. Fisher¹ has devised a "bed-frame" that answers its purpose very well. It consists of two flat iron bars, each with a crutch and strap for the shoulders at one end, and a third or transverse bar that serves to connect the crutch-bars to the head of the bed. The latter bars are also secured to the sides of the bed by bandages. The shoulders being strapped to the frame, and the lower limbs kept still by a weight, any movement of the spine is almost impossible. The American "box-splint" for fractured femur in children answers equally well, if carefully secured to the bed, and steadied also by a weight applied to the lower end of the splint. The duration of the treatment must depend upon the nature of the case and other circumstances, and in the majority of instances is to be estimated by months rather than by weeks. The objections to prolonged recumbency are of course obvious. The treatment is long and irksome, and difficult to carry out efficiently; but Mr. Howard Marsh, and others who advise its practice, have pointed out that the objections raised are somewhat exaggerated, and that the difficulties are by no means insurmountable.²

(2) *Mechanical Appliances*.—A vast number of instruments have been invented to meet the various indications for local treatment. The objections to most of these appliances are the following: They are heavy and often irksome, possess but little adaptability, and must be changed or altered as the child increases in age. The expense would forbid their use—even if considered desirable—to any extent in hospitals. For the most part they take their lower point of support from the pelvis; but the pelvis of a child is so small comparatively, that this basis is often delusive, and it is, moreover, unstable. The result is that few of these instruments are of any use, and that a large number do positive harm. The least objectionable form of instrument is that where the lower support is taken from a broad, rigid band, well moulded to the hips and pelvis. The body and spinal column above the seat of disease are supported by crutch bars that pass from this band to the

¹ Lancet, Feb. 1878.

² Treatment of Spinal Caries in Childhood. British Medical Journal, vol. ii. p. 769. 1881.

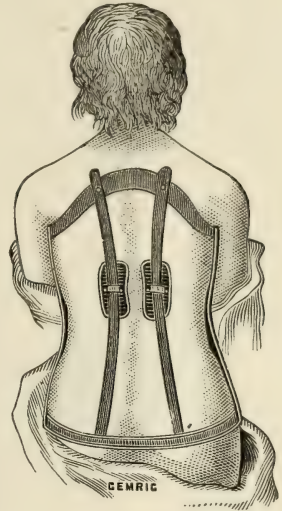
axillæ, and that can be lengthened or shortened at pleasure. The best examples, however, are somewhat cumbrous.

[A better form of apparatus than that described by the author is such as is shown in Fig. 899, the principal support being given by iron uprights on either side of the vertebral column. The cut illustrates the spinal brace devised by Dr. C. F. Taylor, of New York, which, with various modifications, is extensively employed in this country.]

(3) *The use of rigid Jackets with or without Suspension.*—By the introduction of his now well-known “jacket,” Professor Sayre has caused almost a revolution in the treatment of Pott's disease of the spine. When first introduced, this plan of treatment was very widely, blindly, and enthusiastically adopted, and was regarded by some as a panacea for all deformities of the back. Since that time a certain reaction has set in, and there are now not a few who condemn the use of Sayre's apparatus as of little use, and as at least inferior to other modes of treatment. As is usual in similar cases, the truth probably lies between these two extremes, and I feel convinced that Sayre's method affords an admirable remedy for Pott's disease, but at the same time a remedy that must be properly and carefully restricted in its use. The details of Sayre's method are too well known to require minute description. The main features are simply these—extension is applied to the spine by means of suspending the body (Fig. 900), and while in the extended posture a rigid jacket of plaster of Paris is applied to the trunk. The body is suspended by means of a collar beneath the chin and occiput, and by bands beneath the axillæ; a tripod stand is used, and the suspending force is directed through a series of compound pulleys. (Fig. 901.) The first point to be discussed in this mode of treatment is the matter of *suspension*. By means of it the diseased surfaces of contiguous vertebræ are drawn asunder, muscular contraction is overcome, and the column is restored—as regards its curvatures—to something more closely approaching the normal. Facts, however, are greatly needed that will throw more light upon the precise effect of suspension upon the diseased part. Fisher suspended the cadaver of a child who had suffered from Pott's malady. The whole of the body of the first lumbar vertebra had been destroyed by disease, and the contiguous vertebræ were eroded. When in the recumbent posture, the diseased parts were in contact, but on suspension they became separated no less than a quarter of an inch.

It must be remembered that the extending force is the weight of the body below the seat of disease, and that this force will be the greater as the carious part is higher up. It will also increase with the age of the patient and the development of the lower limbs, and will be much influenced by the extent of disease in the column, the destruction of ligaments, the amount of repair, and the degree of muscular contraction. Sayre has pointed out the increase in the patient's height that is to be observed during suspension in cases of “angular curvature,” but it must not be imagined that this increase is due solely to a separation of parts at the seat of disease. Were it so, the advantages of suspension would be very doubtful. He mentions, for example, the case of a man aged 19, with Pott's disease, who gained three-fourths of

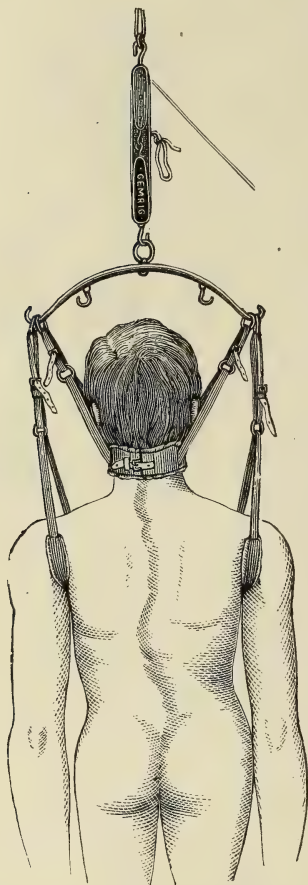
Fig. 899.



Taylor's apparatus for the treatment of Pott's disease of the spine.

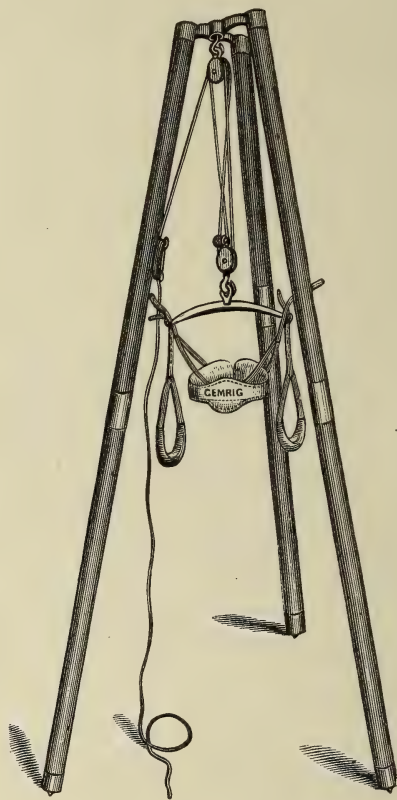
an inch in height on suspension. The production of a gap of this width in the anterior part of the spinal column would be a very questionable advantage. The increase in height, under such circumstances, is due, to a great extent, to

Fig. 900.



Suspension of patient for application of rigid jacket by Sayre's method.

Fig. 901.



Tripod for suspending patient in applying rigid jacket.

the stretching of the column and unfolding of its natural curves; and it is observed in the normal spine of any individual suspended according to Sayre's method.

The object of the *rigid jacket* is to steady the spine, and to retain it, as nearly as possible, in the position which it assumes during extension. It aims at giving physiological rest to the part, it minimizes the effects of shocks and violent movements, and, by preventing mutual pressure and friction of the diseased surfaces, it is presumed that its use will arrest the progress of the malady and favor the process of repair. It is claimed, moreover, for the jacket, that it is inexpensive, readily applied, and composed of materials that can be anywhere obtained; and, lastly, much has been said in favor of its simplicity, its comparative lightness, and the comfort which it affords the patient.

Many objections have, as already mentioned, been made to Sayre's treatment, both as a whole and in its details. The objections to the main principles of the method may now be briefly discussed. It has been urged that suspension pulls asunder the diseased parts, and that, the jacket maintaining them in that position, a cure by ankylosis of the anterior segments of the column is positively prevented. This objection is answered by asserting that the treatment should never be so carried out as to cause an extensive and permanent gap in the column, but that the surfaces should be just prevented from exercising injurious pressure and injurious friction the one upon the other. This exposes the real weakness of the scientific aspect of Sayre's method, for who can tell when the extension is sufficient just to prevent injurious pressure, but not to cause an injurious gap? This question is an important one, and urgently demands an answer. It has been urged, moreover, that the jacket is not capable of supporting the column as maintained by Sayre and others. This objection has especial reference to children, and it is declared that so comparatively slight is a child's pelvis that it affords no proper basis for the support of the column. It is asserted also that the hold which the jacket obtains upon the thorax is not sufficient to support the weight of the body above the seat of disease. In these objections it is assumed that the Sayre's jacket, taking its fixed point from the pelvis, holds up the column in the same manner as would the crutch bar of the steel apparatus for Pott's disease. This is not the case, and the manner in which the rigid jacket supports the spine is more correctly to be compared to the manner in which the four splints around an arm support and maintain position in a fractured humerus.

Some of the details of this treatment may now be considered. In suspending a child, the collar alone is usually sufficient, and by its use very direct traction upon the spine can be obtained. In the cases of elder children and adults, the axillary bands are needed in addition. A collar containing an air pad has been introduced, that renders the extending process less irksome to the patient. As to the amount of the suspension, the rules laid down by Mr. Fisher in his "Essay" are I think the best and the most carefully considered.¹ He details three degrees of suspension. In the *first* degree, the patient is suspended until the toes just touch the ground. He maintains that this should be the extreme degree of extension, and urges that the patient should never be drawn entirely off the floor. He advises this amount of extension for children under 12, with limited destruction of the vertebræ, and for children under 5 in whom more extensive disease exists. In the *second* degree of extension, the patient is drawn up until the heels are raised about two inches from the ground, the "forepads" of the feet being left for the patient's support. This is advisable in more advanced cases of disease, in children under 12, and in severe cases in those under 5. In the *third* degree, the body is raised until the heels are just on the point of being lifted from the ground. This amount of suspension is advised for all cases in adults, or in children over 12, and in severe examples of the disease, between the ages of 12 and 5. Sayre simply advises that the patient be drawn up "until comfortable," and is an advocate for complete suspension. It is certain that patients often experience much relief on suspension, but that fact can hardly afford a proper basis for estimating the amount of force to be used. When the jacket has been applied, the patient must be carefully placed in the recumbent posture while the plaster is still wet, and this practice should meet the objection of those who assert that the jacket may maintain too wide a gap between the diseased parts. In the place of suspension, the jacket may be applied in the recumbent

¹ Op. cit., p. 31.

posture, as advised by Dr. Walker, of Peterborough;¹ or during horizontal extension, or extension by an inclined plane. I would most strongly advise the application of the jacket while the patient is in the prone position, extension being maintained by the inclined plane upon which he lies. The prone posture itself tends to lessen the deformity, and to remove the diseased parts from mutual pressure.

Some few details in the application of the jacket itself may be here mentioned. The vest worn next to the skin must be drawn well down during the application of the plaster bandages, and to effect this end Sayre advises it to be fixed temporarily beneath the perineum. The bandages are made of some loosely-woven material, such as crossbarred muslin, mosquito-netting, or crinoline, and are advised to be about 3 yards long and from $2\frac{1}{2}$ to 3 inches wide. The plaster is to be rubbed into the bandages, which are to be rolled up and then dipped into a basin of water before use. As the plaster so soon spoils, it is well for the bandages to be prepared on the spot for each case as required. During the application of the bandages, an assistant should, with a moist sponge, keep the plaster smooth, and may add, with his hands, a little dry plaster here and there where required. Sayre advises the use of longitudinal strips of tin, that are to be included in the folds of the bandage. They certainly add to the rigidity of the jacket without greatly increasing its weight. Little pads of cotton-wool are to be placed over the iliac spines and any other bony prominences. In the case of females, a pad should be placed over the breasts, to be removed when the jacket is rigid. The "dinner-pad" must not be omitted. This consists of a wedge-shaped pad, inserted beneath the vest over the lower part of the abdomen, with the thin edge of the wedge downwards. It is removed when the jacket is dry, and leaves a potential space between the jacket and the skin. When a discharging abscess exists in a part that would be covered by the jacket, Sayre advises an opening to be made in the following manner: "A piece of oil-silk having been placed over the sinus, a hole should then be cut in the shirt, in order to indicate the size of an opening to be subsequently made in the plaster jacket; and in this hole should be set a folded piece of pasteboard of the same size, and carrying a long sharp pin thrust through its outermost leaf. Now, each turn of the bandage can be carried over the pin without forcing it into the abscess cavity below, and the surgeon is furnished with a guide in making an opening that will lead directly to the diseased surface. When the plaster has nearly set, the bandage should be cut away around the pin until the pasteboard is reached, and an opening made of sufficient size to allow of its easy removal. The oil-silk, which is then exposed, should be starred, or cut into strips from the centre, so that when the strips are reversed they will cover the edges of the opening in the plaster, where they can be glued down with gum-shellac."²

When once applied, the jacket may be kept on for one, two, or three months, or until it becomes so weakened as to be useless. In some of Sayre's cases the jacket was kept on for periods varying from seven to twelve months. This practice is to be condemned upon the grounds of the simplest hygiene, and I think that in no case should the same jacket remain on the patient for a longer period than twelve weeks. The difficulty as to cleanliness, in cases where jackets are long retained, is, to some extent, met by the ingenious plan of drawing the old undershirt off while a new one is drawn on without disturbing the plaster jacket. This is effected by attaching the new shirt to the

¹ See British Medical Journal, Dec. 1878. For an account of Mr. Willett's method of suspension in the prone posture, see St. Bartholomew's Hospital Reports, vol. xiv.

² Spinal Disease and Spinal Curvature, p. 19. London, 1877.

lower border of the old, when, as the old vest is drawn up over the head and removed, the new garment is made to occupy its place.

The jacket, as already noted, must not be used in early or acute cases; and it is, of course, useless when good consolidation of the part has ensued. It is inadmissible, also, in many cases where lung or heart complications exist, and in instances where an abscess projects in any part that would be covered by the jacket. The treatment also would appear, for many reasons, to be inadvisable in quite young children, although Mr. Golding Bird has applied Sayre's jacket with success to an infant under twelve months of age.¹ There are many objections to the use of plaster of Paris for the rigid casing. The plaster is apt to rub out of the bandages; it can rarely be applied so evenly as to exercise everywhere even pressure and support; it is heavy;² and, lastly, it keeps the part from view for a long time, and often prevents serious complications from being detected. An abscess, that was not suspected when the jacket was applied, has shown itself for the first time by an escape of pus beneath the casing, and extensive excoriations also have occurred that might obviously have been prevented had not the jacket been immovable. Many of these objections are met by the use of the poro-plastic jacket. These jackets are made from a prepared felt, and are moulded upon a block so as to form corsets of various sizes suitable to patients of all ages. The patient is suspended in the usual way, and, wet clothes having been wrapped about the body, a corset of proper size is moulded to the figure. This moulding is readily effected, inasmuch as the jacket is rendered very pliable by a momentary immersion in boiling water. It is to avoid the injurious contact of the heated jacket that wet clothes are applied to the body during the moulding process. The felt soon "sets" again. The corset having been properly shaped, is then laced down the front, and, although it forms a perfectly rigid casing for the body, can yet be removed as often as is needed, and as readily reapplied. It has the further advantages over plaster of Paris, of being much lighter, firmer, and more equable in its support, and of requiring a shorter period of suspension.

Agnew describes a jacket of half-tanned leather, which is thus applied: The child is suspended, and a Sayre's jacket applied in the usual way. The patient is kept suspended until the plaster is dry, and the jacket is then cut down in the middle line in front, and removed. From this jacket a cast in plaster of Paris is taken, and upon this the leather corset is moulded. The corset is strengthened by longitudinal strips of steel, and, when applied, is laced down the front. I fail to see the advantage of this apparatus over the simple poro-plastic jacket. Its use involves much trouble and labor, and great inconveniences to the patient, not the least of which is the prolonged suspension.

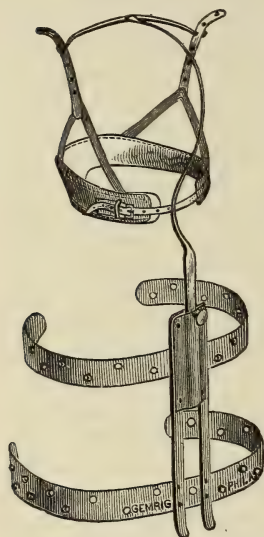
The treatment of Pott's disease varies according to its situation. When the caries is in a part of the spine below the third or fourth dorsal vertebra, a jacket of some kind applied in the suspended posture may be used in the manner already detailed. But when the disease is at or above the third dorsal vertebra, suspension is no longer of use, and the jacket alone would be also of no avail. In such cases the head must be fixed, and the upper part of the column kept rigid and extended by some form of "jury-mast." (Fig. 902.) This jury-mast consists essentially of a rigid bar of malleable iron or steel, that is placed along the back (being moulded to its curve), and extends some way above the head. To the summit of the bar an apparatus is fixed, that

¹ Trans. Internat. Med. Congress, 1881, vol. iv. p. 161.

² The jacket, as applied to quite young children, may weigh five or six pounds. (Trans. Internat. Med. Congress, vol. iv. p. 168.)

keeps the head extended and the affected spine at rest. In Sayre's "jury-mast," the head is, as it were, suspended by the apparatus: extension is kept up, but rotary movements of the head are permitted, as is also some lateral motion. A better apparatus is that advocated by Fisher, which differs from Sayre's instrument in so far that it not only maintains the extended position, but at the same time prevents, by its rigidity, all movements of the head and

Fig. 902.



Jury-mast, for support of head in cases of Pott's disease above the third dorsal vertebra.

cervical spine. In any case, the vertical bar is fixed below, either to a Sayre's plaster jacket applied in the usual way, or to a poro-plastic corset. In the former case it is retained by being included in the folds of the plaster bandages, and in the latter it is fixed to the corset by means of rivets. In either case the necessary firmness needed for the support of the bar is given by several transverse pieces of metal attached to the lower part. There can be little doubt but that the latter method of fixing the jury-mast is infinitely the more advantageous. In these cases of disease above the third or fourth dorsal vertebra, recumbency is almost imperative as a preliminary measure, and should be insisted on as long as the mischief is acute and progressing actively.

The general treatment of the malady needs little detail. The patient's health must be attended to: change of air, especially to the seaside, is to be advised, and a liberal diet should be ordered in all cases where such a diet is obtainable. If the state of the digestive organs does not forbid its use, cod-liver oil should be given throughout the whole course of the disease, especially when the patient is a child and scrofulous. Among other drugs,

iron, iodine, phosphorus, and quinine are of service, and one of the most suitable drugs for children is, perhaps, the compound syrup of the phosphate of iron.

The treatment of the *abscess* is a subject of much difference of opinion, and on this matter the reader is referred to the article on Abscesses in a previous volume.¹ As far as my own experience goes, I should advise an evacuation of the matter by the aspirator at as early a period as possible, and I do not think that facts support the practice of temporizing, with the hope—which is always very meagre—that the pus will be absorbed. When the collection re-forms after the puncture, it may be again aspirated, and this procedure may be repeated a great many times. After each operation, the skin about the puncture should be kept for a while painted with collodion, and in any case every care should be taken to protect the parts from friction and injurious pressure.

In the majority of cases, the skin at the most prominent point of the abscess will become greatly thinned, and possibly inflamed, and the condition will be such that the collection, if left any longer, will discharge itself through the integuments. In anticipation of this, a free opening should be made into the abscess under antiseptic precautions, and the wound should be dressed antiseptically until such time as antiseptic measures are considered unnecessary or unadvisable. At each dressing, it is well that the abscess-cavity should be gently syringed with a weak carbolic solution (1 to 100 parts).

¹ See Vol. I., page 760.

If the opening be in the loins or back, or in any part that would be covered or interfered with by any jacket or mechanical apparatus, then should such appliances be discontinued, and the recumbent position be insisted on. When the discharge has diminished, a jacket may be applied with a hole in such part of it as corresponds to the sinus. This aperture may still be dressed antiseptically, and the patient allowed to get up. [See page 560.]

DISEASE OF THE ATLO-AXOID REGION.

Diseases of the bones and joints in this region, although they differ in no way pathologically from like diseases in other parts of the column, are yet conveniently considered apart on account of the distinctive clinical features which they present. The special features of disease in this part depend upon the peculiar structure and outline of the bones themselves as compared with the other vertebræ, upon the peculiarity of the joints between them, the free and elaborate movements in those joints, and the very close proximity of that most important part of the cerebro-spinal system, the medulla oblongata.

PATHOLOGICAL ANATOMY.—The parts concerned in this region are the atlas, the axis, and the condyles of the occipital bone, together with the atlo-axoid and occipito-atloid joints. The disease in these parts may assume very variable aspects. As a rule, it consists essentially of an arthritis of one or other of the joints just named. This arthritis is nearly always associated with gross bone-mischief, and may be attended with very extensive necrosis or caries, of either the atlas or the axis, or both. There are cases where a caries or a necrosis of these bones has appeared to exist independently of any joint-mischief, and that such a condition may occur, is a matter beyond doubt. But such cases are not common. Such is the arrangement of the articulations in this region that external bone-disease is scarcely possible independent of joint-mischief, and in any case where a fairly extensive necrosis or caries exists, it may be safely concluded that some one or other of the neighboring articulations is involved. In any case the mischief most usually commences in the joint, but it may commence in the bone, and this especially applies to cases where the anterior portions of the atlas or axis are carious or necrosed.

There is nothing peculiar about the bone-affection or joint-affection as it appears in this region. The caries and the necrosis are of the same nature and disposition as caries and necrosis elsewhere. The joint-malady usually assumes the form known elsewhere as "white swelling." It is nearly always chronic, is apt to lead to "pulpy degeneration" of the soft parts involved, is prone to induce extensive mischief in the cartilages and bones, and is usually associated with suppuration. Deformity of the affected joint from partial dislocation is common, as is also extension of the suppuration and the formation of sinuses; and lastly, the malady may end in a more or less complete ankylosis. Indeed, in all their features—not excluding their etiology—a large number of the joint-affections in this part are identical in their general pathological features with the white swellings or strumous joint-diseases of other regions.

Sometimes the disease in this segment of the column may follow upon injury alone, and then the pathology of the articular or osseous changes is identical with that of like changes elsewhere that depend upon a like cause. The same remark applies to those instances of atlo-axoid disease that are considered to be due to syphilis; of the two joints mentioned, the atlo-axoid articulation would appear to be more frequently involved than that between the atlas and occiput, but on this point there are some differences of opinion.

In diseases of the atlo-axoid joint, some displacement of the bones is very common, and indeed usual. This takes the form of a sliding forward of the atlas upon the axis. It may be presumed that this displacement is permitted by a softening of the ligaments around, and especially of the transverse and odontoid ligaments. The odontoid process thus encroaches upon the spinal canal, and the most serious results of this disease are apt to follow therefrom. The atlas may slide symmetrically forwards, but more usually the displacement is more or less unilateral, one lateral mass of the atlas being in advance of the other. The displacement is usually very slow in its occurrence, and any sudden displacement in this direction causes instantaneous death. It follows from the deformity that a very sharp bend is given to the cord opposite the seat of mischief, and it is a matter of much interest to note to what extent the spinal canal may be encroached upon without a fatal result ensuing therefrom. Thus, Sir James Paget has recorded an instance of disease in this region, where the atlas, and with it the occiput, had slid so far forward on the axis that the spinal canal was more than bisected by the posterior arch of the atlas. The odontoid process had remained with the axis. The bones were greatly ankylosed in this position, so that the condition must have existed long enough for this tardy mode of cure to be effected.¹ In some cases the odontoid process may become separated from the body of the axis, and, adhering to the atlas, may be carried forward with that bone when it is displaced.²

Dislocations at the occipito-atloid joint from disease are very rare. According to Follin and Duplay, they may be bilateral or unilateral, and consist, as a rule, of a displacement of the occipital bone backwards. In only one recorded instance was this bone displaced forwards.³

When caries and necrosis exist in this part, they usually involve the anterior portions of the bones, the parts most commonly implicated being the anterior arch of the atlas, the body of the axis, and the odontoid process. The anterior arch of the atlas and the odontoid process have separated almost entire, as sequestra, and considerable portions of the body of the second vertebra have been lost in like manner. Or these parts may either alone or conjointly be more or less carious,⁴ and in one case, to be again alluded to, no trace of the odontoid process was to be found after death.

In some cases where the joints are the parts mainly involved, the process may run its course and end in cure without any abscess appearing, although some evidences of suppuration are usual. The suppurative process set up by the disease, no matter whether primarily in joint or in bone, tends to invade the adjacent soft parts, and the abscess formed may present at the sides, or at the back of the neck. Having reached the connective-tissue layers of the neck, the abscess may extend in a downward direction and appear in a distant part. Thus, Smith, of Dublin, records a case in which an abscess proceeding from occipito-atloid disease presented itself in the supra-clavicular fossa, and ultimately opened into the lung. Bryant describes a case in which the abscess formed behind the sterno-mastoid muscle, and in which from the opening in the skin that was formed, a piece of the lamina of a vertebra was discharged.⁵

Very commonly, the abscess presents itself in the tissue behind the pharynx (retro-pharyngeal abscess), and this is especially the case in instances of bone-disease in the anterior parts of the upper cervical vertebræ. This retro-pharyngeal

¹ Med.-Chir. Trans., vol. xxxi. p. 286, 1848.

² Shaw, Holmes's System of Surgery, 2d ed., vol. iv. p. 140.

³ Traité élémentaire de Path. Ext., tome iii. p. 73, 1868.

⁴ See case by Dr. Ogle, where the atlas, the axis, the occipital condyles, and the edge of the foramen magnum were all carious. Trans. Path. Soc., vol. xv. p. 19.

⁵ Manual for the Practice of Surgery, 2d ed., vol. i. page 278.

ryngeal abscess may burrow down behind the pharynx and reach even to the mediastinum. In other cases the pus may go towards the spinal canal, and may form a collection between the dura mater and the bone: or having pierced that membrane it may enter the arachnoid space, and lead to a rapidly fatal result. Follin and Duplay assert that the vertebral artery may be opened by the suppurative process, and such a hemorrhage take place into the spinal canal as to lead to compression of the cord. As in Pott's disease, the mischief may progress to a fatal issue without remission, or a cure may follow without any previous evidence of abscess, or a like good result may follow after the abscess has appeared, and that too after it has discharged itself through the skin.

In cases where ankylosis has taken place, the outlines of the bones involved may be very confused, and the deformity remarkable. In a case noted by Sir Wm. Lawrence, the atlas, axis, and occipital condyles were fused together in one firm mass. The bones had been partially dislocated from one another, and the odontoid process was thrust so far into the foramen magnum as to really occupy the cranial cavity.¹ In a specimen described by Dr. Lochee and Mr. C. H. Moore, the four upper cervical vertebræ and the occipital condyles were fused together. The bones were all much compressed and distorted, and their outlines very confused. There was no trace of the odontoid process. The bodies of the two upper cervical vertebræ had invaded the foramen magnum, and were practically in the cranial cavity. The spinal canal, at the seat of disease, was, as may be imagined, much diminished in capacity.² Lastly, it is to be noted that the spinal cord may be compressed or crushed by fragments of bone separated in the progress of the disease.

ETIOLOGY.—The etiology of disease in this region is very similar to that of Pott's malady. The disease occurs mostly in childhood and youth, and is ascribed in the bulk of instances to the influence of scrofula. It is rare in those of mature age, and very rare in the old. The mischief may also follow after injury, and this would seem to be one of its most frequent causes in those cases that appear late in life.³ Cold, unwonted use of the part—as in carrying weights upon the head, etc.—rheumatism, gout, etc., have been somewhat vaguely regarded as active causes in producing disease of the upper cervical spine. Syphilis would appear to be a frequent cause of the disease, and especially of that form of it that principally attacks the bone. There are several recorded cases where disease of the upper vertebræ has followed upon deep ulcer of the pharynx, and it is very probable that all these examples have been due to syphilis.

SYMPTOMS.—The symptoms of spinal disease in this region may be conveniently arranged under the heads, (1) Pain, (2) A certain rigidity of the neck, (3) Swelling, (4) Deformity, (5) Signs of abscess, and (6) Evidence of pressure upon the cord.

(1) *Pain* is very often one of the first signs of the malady under consideration. This pain is mostly complained of along the course of one or more of the following nerves: the great occipital, the small occipital, the great auricular, the superficialis colli, and the descending branches of the cervical plexus, viz., the sternal, clavicular, and acromial nerves. It is necessary to remember that the first cervical nerve escapes between the occiput and the atlas, the second between the atlas and the axis, and the third beneath the latter bone. So

¹ Med.-Chir. Trans., vol. xiii. 1827.

² Lancet, vol. vii. 1867, p. 637.

³ See example of occipito-atloid disease, ending in ankylosis, in a man aged sixty-four. It followed upon a fall on the head. There was no fracture. Med.-Chir. Trans., vol. xxiv. 1841.

that in disease of this region of the column, the first three cervical nerves may readily be implicated, and, as the branches above named are all sensory nerves, the distribution of the pain may be very definite. The two occipital nerves are branches of the second cervical; the great auricular and superficialis colli, of the second and third cervical; and the descending nerves, of the third and fourth cervical. Thus the two occipital nerves are the two most likely to be irritated, together with those parts of the great auricular and superficialis colli that are formed by the second cervical. The third nerve can only be implicated when the disease extends to the lower part of the axis. The distribution of pain, therefore, may be of some value in localizing the mischief. As the upper cervical nerves lie close to the bone where they issue from the spinal canal, it can well be imagined that they are early and readily affected by any inflammatory changes in those bones. Thus, then, among the first signs of disease in this region is pain about the back of the head and upper part of the neck, or about the sides of the neck and sometimes in the ear, or less frequently about the shoulders and upper part of the chest. The pain varies in intensity in different cases, is commonly neuralgic in character, and often very severe. It is made worse by any pressure upon the head that brings the occipital condyles forcibly on to the spine, and by movements that concern the joints of the first two cervical vertebræ. It is often increased also by any sudden movement or any jolting of the column. Hilton says that the pain in disease of the lower cervical, the dorsal, and the lumbar spine, is "almost always symmetrical," but that in disease involving the first two joints of the column it is unilateral: and that this feature serves to point out which side of the vertebræ is involved.¹

(2) In all cases, a certain amount of *stiffness in the neck* becomes apparent, and is among the earliest and the most striking symptoms of the disease. The movements that are limited will depend to some extent upon the parts involved. If the occipito-atloid joint be alone implicated, all nodding movements of the head will be arrested, while some rotation of the head will still be possible. If, however, the disease involve only the atlo-axoid articulation, then will all rotary movements be checked, while the nodding motion may still be effected. As a matter of fact, however, both of these movements are usually more or less arrested in disease of this region, no matter how limited it may be. The parts are so intimately related that movement of one joint can hardly fail to disturb the other joint, and while nodding movements may possibly be effected without great discomfort in atlo-axoid disease, it is very improbable that rotary movements could be made with a like ease should the malady attack the upper of the two articulations. In most cases, the greater part of the whole of the cervical spine is rigid. If the patient be asked to turn his head, he effects the movement by rotation of the dorso-lumbar spine, or by turning of the entire body; and any nodding movement of the head he replaces by a bending or bowing movement of the trunk.

(3) *Swelling* about the nape of the neck soon becomes obvious, and this may be such as to obliterate the suboccipital fossa. It varies greatly in amount in different cases. The swelling may involve some part of the side of the neck, appearing very deeply seated, or it may occur in the post-pharyngeal region. In the latter region it may cause early dysphagia. The more superficial swelling may be associated with some tenderness, and, in thin subjects and in acute cases, with some decided increase in the temperature of the skin.

(4) After the disease has existed for a variable period, some *deformity* usually becomes obvious. Before this, however, takes place, the patient will

¹ Lectures on Rest and Pain, third ed., 1880, page 92.

possibly have adopted a carriage more or less typical of lesion in the region of the column now under notice. The head may be kept bent forwards, or backwards, or to one side, or in the position of rotation; the first mentioned position is the most common. Sometimes the patient may appear to be unable to support the head by means of the usual muscles; he prefers the recumbent posture, with his head sunken in a pillow, and, if required to get up, will support his head with his hands. The actual deformity as a rule depends upon the sliding forwards of the atlas upon the bone beneath. When this occurs, the chin and face are advanced, and are stiffly poked forwards. The roundness of the upper part of the back of the neck is lost. The spine of the axis becomes prominent, and may be readily felt or seen. This deformity when present is very characteristic, and is well represented by Mr. Shaw in a drawing in his monograph already referred to. The displacement, when in any way well marked, may be sometimes felt by examination of the part through the upper and posterior part of the pharynx.

(5) The disease may run its entire course, and end in cure, without any *abscess* appearing externally. As a rule, however, abscess does appear, although that appearance may be long delayed. The purulent collection may present itself at the back or side of the neck. In the latter position it will be deep-seated, and may cause severe symptoms and great difficulty in diagnosis. Such an abscess will, however, have—apart from the spinal disease—no especial characters that separate it from other deeply-seated cervical abscesses. In some cases (and in those particularly that depend upon necrosis of the anterior parts of either of the two upper vertebræ) the purulent collection may appear as a “post-pharyngeal abscess.” An abscess in this situation may cause very obscure and very severe symptoms. In a case already associated with evidences of disease in the upper cervical region, a swelling appears behind the pharynx, that may in time increase so as to push forward the soft palate, or may extend so low down as to be obvious from the mouth. This swelling is associated with much pain and distress, with considerable difficulty in deglutition, and often with alarming dyspnoea. The cause of this dyspnoea has in more than one recorded case been overlooked, and tracheotomy proposed or practised for its relief. Very often the abscess presents itself at the same time at the side of the neck. Thus, Mr. Hilton¹ records a case of a child, aged twelve months, who in addition to the post-pharyngeal swelling had an abscess that extended to the angle of the jaw, pushing forwards the trachea and carotid vessels, and lifting up the sterno-mastoid muscle. The collection was opened in the neck, and the pharyngeal tumor at once subsided. Sir James Paget² gives an instance where the post-pharyngeal abscess was complicated by an extension of suppuration to the parotid region, associated with rigidity of the jaw. The collection opened spontaneously through the pharynx, and a severe hemorrhage followed. The hemorrhage recurred and proved fatal. The autopsy showed caries of the anterior arch of the atlas, and an abscess-cavity about the carotids, and between the tonsil and the parotid gland. The source of the bleeding was not discovered. The post-pharyngeal abscess may open into the pharynx, or may discharge itself through the integuments of the neck, but an opening in the former situation is the more common. The bursting of the abscess into the pharynx may cause death by asphyxia, the matter finding its way into the larynx. Or, independent of its bursting, the collection may cause death by asphyxia, that end being brought about by pressure.

Several cases are recorded where the mischief in the bones has been secondary to an ulcer of the pharynx, and in all these instances the disease would appear to have been due to tertiary syphilis. The following was a case of

¹ Op. cit., page 135.

² Holmes's System of Surgery, 2d ed., vol. i. p. 133.

this kind:¹ The patient, a man aged 35, had an extensive syphilitic ulcer of the pharynx, that had destroyed the soft palate and exposed the anterior arch of the atlas. This process of bone necrosed *en masse*. Other instances of pharyngeal ulcer associated with bone-disease in the cervical spine are evidently secondary to the osseous lesion, and due to extension forwards of the destructive process. Through these ulcers, or through the abscesses after evacuation of their contents, sequestra have been discharged or removed by operation. Thus, in the case just mentioned, the whole of the anterior arch of the atlas was removed through the pharynx as a sequestrum. Mr. Keate² has given an account of a like operation. Mr. Bryant³ records the case of a woman who coughed up, as a sequestrum, the odontoid process, and who, nevertheless, made a good recovery. The same surgeon has also seen "the anterior half of the atlas, with its articular facets," expectorated, and a cure follow its elimination. Mr. Hilton also details the case of a patient who coughed up the anterior arch of the atlas, the sequestrum having escaped by way of a pharyngeal ulcer.⁴

(6) The symptoms that depend upon *implication of the cord and the upper spinal nerves* are very varied. Some of these symptoms have already been alluded to in dealing with the matter of *pain*, and I now propose to consider some of the graver evidences of this complication. The period at which these symptoms make their appearance is very uncertain. The disease may run its entire course, and end in cure, without cord-symptoms of any kind having been observed; or, on the other hand, such symptoms may be among the earliest evidences of the malady. The first evidences of these nerve-complications may be very trifling and obscure, while in not a few cases the first and only sign of injury to the cord has been sudden death. Such instances of sudden death are, probably in all examples, due to a giving way of the transverse and odontoid ligaments, whereby the atlas, bearing the entire weight of the head, slides forward upon the axis, and thus crushes the lower part of the medulla. In most instances, however, the symptoms develop very slowly, and proceed from bad to worse in progressive cases. There may at first be tingling or darting pains in one or other of the limbs, usually in the upper extremities. This may be followed by a feebleness that may pass on to more or less complete paralysis. Some few cases are recorded where pain and weakness have appeared in both arms and in both legs at once. The paralytic symptoms may be preceded by spasmodic contractions of various muscles, and by convulsive movements of the limbs. In the case recorded by Dr. Lochee and Mr. C. H. Moore, and quoted above, the fingers and wrists were contracted in the flexed position, and a like continuous spasm was noted in the feet; there was muscular weakness, but no paralysis. In a case seen by Mr. Shaw, "the muscles became affected with tonic spasm; the whole body was so rigid that on turning the patient in bed she rolled with the stiffness of a corpse having rigor mortis; that condition lasted for a month; it gave place gradually to ordinary paralysis, from which she eventually recovered."⁵ The paralysis may vary greatly in extent; it is apt to be general rather than local, and although some patients become paraplegic merely, and others exhibit no more extensive paralysis than loss of power in one arm, yet the bulk who show motor defects show those defects over an extensive series of muscles, and exhibit a condition that varies from general muscular weakness to general paralysis of parts below the neck. Sensation is much less frequently impaired than motion, and would appear to be scarcely ever im-

¹ Med.-Chirurg. Trans., vol. xxxii. p. 64. 1849.

² Op. cit., vol. i. p. 281.

³ Loc. cit., p. 145.

⁴ Medical Gazette, vol. xii. 1835.

⁵ Op. cit., p. 113.

paired without motor defects; but with extensive paralysis there may be considerable anæsthesia. In the cases of wide-spread paralysis, there is usually loss of control over the bladder and rectum.

A fatal termination may be preceded by certain cerebral symptoms—vertigo, headache, vomiting, convulsions, and epileptiform attacks; or death may be sudden, from a sudden crushing of the cord in the manner above detailed.

In addition to these particular symptoms, the patient with disease of the upper cervical spine may exhibit certain general symptoms—such as fever, marasmus, hectic, fatty and amyloid degeneration of viscera from long-continued suppuration, etc.

DIFFERENTIAL DIAGNOSIS.—In the diagnosis of disease in the occipito-atloid and atlo-axoid regions, the following sources of fallacy must be eliminated: *Muscular rheumatism* in the cervical region may cause stiffness of the neck, with pain on movement, and has been mistaken for the graver malady. The spinal disease, however, is most common in the young, at an age when this form of rheumatism is quite uncommon. The rheumatic affection is associated with a good deal of tenderness on pressure, a symptom absent or but slightly marked in the spinal ailment. Steady pressure of the head vertically down upon the vertebral column will not increase the pain in muscular rheumatism; nor is that pain as much aggravated by jolts and sudden movements as it is in the spinal affection. The neck, in severe muscular rheumatism, will be quite stiff, but in the more deeply seated disease, rotation of the head may remain comparatively free, while nodding is impossible, and *vice versa*. The rheumatic affection is associated with no deformity, such as projection of the spine of the axis. It may be attended with pains in the limbs, but these can easily be differentiated from the nerve-pains in the spinal disease. The progress of the case and the effects of treatment will readily remove in time any difficulties in diagnosis.

A *deep-seated cervical abscess*, associated with rigidity of the neck, pain on movement, etc., may cause error in diagnosis, and the source of the abscess may be wrongly imputed. The simple cervical abscess does not tend to cause rigidity of the neck until it is well advanced, whereas the abscess due to spinal disease will have been preceded by rigidity of the parts for perhaps a considerable time. In the simple abscess, the neck is apt to be drawn to one side, a position uncommon in the spinal affection. In the simple abscess the pain is not apt to be increased by carefully applied pressure to the vertex; there will be an absence of spinal deformity, of post-pharyngeal mischief, and of cord and nerve symptoms. Lastly, the source of the non-spinal abscess may be made out, and a positive diagnosis be thus established. *Torticollis*, *phlegmon of the neck*, and *glandular disease* are enumerated by some authors as affording possible sources of fallacy in diagnosis; but the points of resemblance between these affections and the spinal malady are not sufficiently close to merit further notice.

PROGNOSIS.—The progress of the disease varies considerably both as to the manner and the rapidity of its advance. Within a short time from the commencement of the disease, the patient may be bedridden; and, on the other hand, cases are met with like one recorded by Shaw, where a patient, a servant-girl, continued her work without inconvenience until the deformity, due to the sliding forwards of the atlas on the axis, was well marked. On the whole, the prognosis in this malady is grave, the seriousness of a case depending mainly upon the implication of the cord. Although the majority of the deaths from this disease are due to nerve-complications, a fatal result may be brought about in other ways. Thus, the patient has sometimes died

from asphyxia, owing to an inability to cough or expectorate. The escape of pus into the larynx from a post-pharyngeal abscess has caused death by a like means. The rigidly retained recumbent posture has led to fatal hypostatic congestion of the lungs; and other patients have died of marasmus, or of some of the evils that attend upon suppuration and discharging sinuses. The least serious form of paralysis is that which involves the upper extremity, especially when it implicates but one limb, or but a part of one; the most grave form appears as equal paralysis of both lower extremities, or of the entire body. It is well, however, to remember that even the most severe forms of paralysis may be recovered from in this malady. Thus Shaw cites the case of a man aged 48, with disease of the atlo-axoid articulation, who was, for six months, entirely paralyzed "from the head to the toes," and who, nevertheless, made a perfect recovery. It is obvious that age influences the prognosis considerably, and that the younger the patient the more probable is a good result, other things being equal.

As the cure is by ankylosis, any deformity that has developed must persist, as must also a considerable defect in the range of movement. Cases have, however, been recorded here and there, where a good deal of movement has been recovered after extensive disease that has involved the bones rather than the joints. Thus, in a case where nearly the entire anterior arch of the atlas came away as a sequestrum, the patient recovered with the rotatory movements of the head "almost perfect," and with but incomplete limitation of the nodding movements.¹

TREATMENT.—The general treatment of these cases of spinal disease needs no comment. The local treatment should be such as to insure absolute rest to the part, and to prevent displacement of the bones. These ends can only be properly secured by a rigidly maintained recumbent posture. The patient should be placed absolutely flat upon his back, upon a firm and level mattress. Beneath the nape of the neck, a small, firm cushion should be placed; and the occiput may rest either upon a very slight, soft pillow, or upon a circular pad, so hollowed in the centre as to relieve the more prominent part of the occiput from any injurious pressure. The importance of the small, hard cushion beneath the nape of the neck—as first advised by Mr. Hilton—cannot be over-estimated. Without such a support, the recumbent position becomes almost useless. Mr. Hilton has shown by a reference to anatomical facts, and by experiment upon the dead body, that this little cushion supports the axis and tends to lift it up. By this means the gliding forward of the atlas upon this bone is rendered impossible, compression of the cord is thus avoided, and the slight flexure given to the spine acts by way of slight extension upon the diseased parts. The head should be kept fixed in the position indicated, by two large sand-bags, placed one on either side of the head and neck. In cases where the patient is restless and apt to move the head, immobility may be secured by a linen cap that comes well forward on to the forehead, and is secured under the chin and around the neck. To the front of this cap, linen bands are attached transversely, and secured to the sand-bags. By these means the head may be kept secured to the bed, and none but the most trifling movement permitted. This position should be maintained strictly for as many months as may be required. From three to six months will be sufficient in the bulk of cases. The recumbent posture rigidly maintained in the manner just indicated, is the only safe position for a patient with active disease about the atlo-axoid region. Hilton records the case of a little girl, aged 5, who presented very severe symptoms in connection with

¹ *Med.-Chir. Trans.*, vol. xxxii. page 64.

this spinal disease. The recumbent posture was ordered and maintained most rigidly. In 14 days the child had remarkably improved, when an officious nurse, in direct disobedience to orders, thought fit to ask the child to sit up. The child did so; the head fell forwards, and the patient was dead.¹ The relief that the recumbent posture often gives to some of the most urgent symptoms of the malady is well shown in the following case, also recorded by Mr. Hilton. The patient—a young woman—when seen by Mr. Hilton, was almost pulseless, was unable to swallow, was scarcely breathing, and not quite conscious, and was paralyzed nearly completely in both arms and legs. She was propped up in bed by pillows at her back, with her head inclined somewhat forwards. Her death appeared imminent. She was at once laid flat upon the bed, with a pillow beneath the nape of her neck, as above described. The sense of suffocation was immediately relieved, and the severity of the other symptoms soon diminished. She retained the recumbent posture for six months, and then left the hospital cured.

When it is believed that firm consolidation has taken place, the patient may be allowed to get up; but before such a change in position is permitted, the head and neck must be fixed in some rigid apparatus. This apparatus may consist of a well-moulded stock of gutta percha, leather, or poro-plastic felt, and should be well secured below to the shoulders, back, and chest, and above to the chin, lower jaw, and occiput. Or, in the place of these appliances, a jacket may be fitted to the trunk, and a jury-mast applied in the manner indicated when dealing with the treatment of Pott's disease. The diseased parts should be thus maintained until perfect cure has resulted. In no case should any of these instruments be used as a preliminary mode of treatment, to the disregard of the recumbent position. In all cases they should be merely supplemental or secondary to the treatment by posture. Those who deprecate prolonged recumbency urge that many cases do well and end in cure when this measure has not been made use of. But it must be remembered that cases of cure under these circumstances are exceptional, and they should be regarded merely as fortunate occurrences, and not as furnishing grounds for the selection of a mode of treatment. It is, perhaps, needless to observe that attempts to reduce the dislocation, such as have been practised by some surgeons, are quite unjustifiable, and are more likely to end in death than in any improvement.

With regard to the abscess, it should be opened at the earliest opportunity, and a free vent given to the pus. This especially applies to post-pharyngeal collections. These abscesses should be opened by a small puncture that may be subsequently enlarged, and the operation should be performed while the patient is in the recumbent posture, in order that the escaping pus may run down into the gullet, rather than into the larynx, as might readily occur, especially when the subject of the operation is a child. When the purulent collection presents itself both at the side of the neck and behind the pharynx, it may be well to open it in the former situation, according to the method advocated by Hilton.² This surgeon has given an example of the opening of an abscess in the neck that presented itself also behind the pharynx. A good result followed. Any sequestra that may be exposed by the opening of the pharyngeal abscess, or by the extension of a pharyngeal ulcer, may be removed by forceps, provided that they are quite loose. Large portions of both the atlas and the axis have been removed through the mouth under these circumstances. In cases due to syphilis, a specific treatment must of course be adopted.

¹ Op. cit., page 111.

² See Vol. I., page 761.

[ADDITIONAL REMARKS ON SPINA BIFIDA.]

Some reference should be here made to the Report of the Committee appointed by the Clinical Society of London to investigate the subject of Spina Bifida, which has been made public since the completion of Mr. Treves's article.

This committee divides cases of spina bifida into three classes, viz.: cases in which the protrusion involves the membranes only (*spinal meningocele*), cases in which the cord and membranes are both involved (*meningo-myelocoele*), and cases in which the cavity of the sac is formed by the central canal of the cord itself (*syringo-myelocoele*). The second variety is the most, and the third the least, common. In meningo-myelocoeles the spinal cord with its central canal is found within the median, vertical portion of the sac, and at this part there is no covering of true skin; from this intramural portion of the central nervous system arise the nerve-roots by which the sac is traversed. A somewhat similar classification is adopted by Prof. Humphry, of Cambridge, who recognizes as the most common form of spina bifida the *hydroschisis externa anterior*, in which the fluid occupies the subarachnoid space in front of the cord, this, with the nerves, being stretched backwards and outwards upon the sac, and being there "confluent, together with the arachnoid, pia mater, and dura mater, or their representatives, in the thin membrane which forms the hindmost part of the wall of the sac;" and regarding as rarer varieties the *hydroschisis externa posterior*, or hydro-meningocele, in which the fluid is found behind the cord, which does not enter the sac, and the *hydroschisis interna*, or hydro-myelocoele, in which the fluid occupies the central spinal canal.

The Committee of the Clinical Society believes that the theory best explaining the pathological anatomy of spina bifida, is that which assumes a primary defect of development of the mesoblast from which are formed the structures closing in the vertebral furrow. Three analyses of the fluid of spinæ bifidæ made for the committee by Halliburton showed uniformly a decided trace of sugar, with a diminution in the quantity of proteids, which appeared to consist entirely of globulin.

With regard to the *treatment* of spina bifida, the committee's statistics, while confirming the opinion that Morton's iodo-glycerine injection affords the most successful mode of treatment, do not show as large a proportion of cures as has been reported by that author himself, benefit having been obtained from the operation in only 39 out of 71 cases. Of 23 cases referred to by the Committee as having been treated by excision, 16 are said to have been successful.

OPERATIVE TREATMENT OF POTT'S DISEASE.

Mr. Treves has, since the publication of this article, recorded cases in which spinal abscesses were opened, with antiseptic precautions, from the loin, and the affected vertebræ, whether carious or necrosed, then submitted to direct treatment, as would be done in cases of bone-disease of other regions. Similar operations have also been performed by Bœckel, Byrd, R. Davy, and Mac-ewen. The latter surgeon reports a cure by trephining the vertebral laminæ for the paraplegia of Pott's disease, and in an analogous case recorded by Maydl, the patient at least recovered from the operation.]

INJURIES AND DISEASES OF THE EYES AND THEIR APPENDAGES.

BY

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AMONG the five special senses, royal importance has, at all times, been conceded to sight. The value of the eye, in the animal economy, has drawn to its diseases a never-flagging interest. As we approach this mystic temple to inquire into divine secrets, let us walk lightly, for we are treading on holy ground. Shut off the light of the eye, which is the cheer of the soul, and the blackness of darkness rushes in to overwhelm the stoutest heart. Had not the "drop serene" quenched the orbs of Milton, his ecstatic invocation to Light could never have been conceived. It is said of Shakespeare that when he wrote he dipped his pen in his own heart. That is the main secret of his immortality. The truly scientific spirit is ever humble, supremely desiring to know and to tell the truth. In entering on our favorite study, shall we not bring to bear upon it an earnest and honest intelligence? To this end a brief outline of the structures composing the organ whose injuries and diseases we are to investigate, must inaugurate our work. In the pinching interests of brevity we must assume that the reader has an adequate knowledge of the anatomy and physiology of the eye, which needs only to be refreshed. First in the order of solid importance, let us take up the cavity in which the eye is securely lodged, and successfully discharges its functions.

ANATOMY OF THE EYE.

THE BONY ORBITS.—These are hollow pyramids, with bases presenting forwards and outwards, and apices backwards and inwards. The axes of the two cavities intersect over the sella turcica. This divergence of the orbits affords a larger field of vision and greater circumspection. The most firm and resisting part is the bony ring that forms its base. The prominence of these bony guards, with the nose between them, protects the eyes from the disastrous force of injuries. The upper wall, slightly arched, is formed by the frontal and sphenoid bones, and supports the anterior lobe of the brain. In its middle, the orbital plate is very thin, and liable to be fatally pierced by direct thrusts from below. I recall the case of a man, brought to the hospital without history, and delirious, and who soon died. The end of a small knife-blade was found broken off in this plate, penetrating and causing abscess of the brain. On this wall are found the optic foramen, the pit for lodging the lachrymal gland, a little depression for the trochlea, and a supra-orbital foramen or notch. The inner wall, furnished mainly by the ethmoid, is smooth and parallel with

its fellow, completed anteriorly by the lachrymal and nasal process of the superior maxillary. Here is seen the vertical groove in the os unguis that lodges the lachrymal sac, and becomes below the bony nasal duct. The lower wall, made up chiefly by the orbital plate of the superior maxillary, slopes a little downwards and outwards. In it is seen the groove for the infra-orbital nerve. The outer wall, supplied by the malar and sphenoid, is very solid, sloping outwards, and giving divergence to the orbits. The scope of vision thus afforded, supplemented by rotatory movements of the head, enables us to sweep the horizon with our view.

Near the apex of the cavity we find two large fissures, the sphenoidal and sphe-no-maxillary, giving passage to vessels and nerves; the former communicating with the cavity of the cranium, and the latter with the zygomatic fossa. The motor nerves that supply the extrinsic and intrinsic muscles of the eye, the ophthalmic branch of the fifth nerve, some filaments of the sympathetic, and the ophthalmic vein, all pass into the orbit through the sphenoidal fissure. The infra-orbital artery and nerve pass through the sphe-no-maxillary fissure, into the groove in the floor of the orbit. In blows on the temple, blood may find its way through this fissure, and give rise to ecchymosis of the conjunctiva. I once saw periostitis following the extraction of an upper molar tooth, the pus passing through this fissure into the orbit, and pointing at the lower and outer margin, below the angle of the eyelids. In fractures of the base of the skull, the crack often passes through the sphenoidal fissure, and gives rise to conjunctival ecchymosis. It may likewise traverse the optic foramen, contusing, tearing, or compressing the nerve, and giving rise to serious disturbances of sight. A sharp instrument may be thrust through the sphenoidal fissure with fatal injury to the brain. A royal example, in the case of Henry the Second, of France, is quoted by authors.

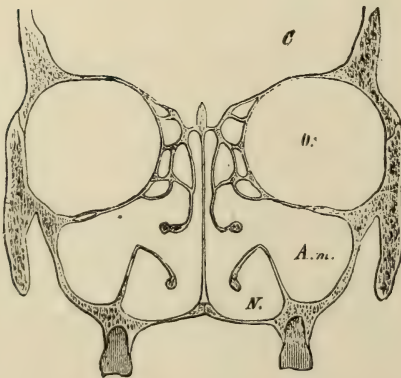
The size of the orbital cavity, with its fissures and foramina, is perceptibly diminished by the periorbita that lines it throughout, continuous at the base with the pericranium, and at the apex with the dura mater. The periorbita is thin and somewhat loosely connected with the bones, being easily separated by extravasations of blood or collections of pus.

In close relation to the orbit, are several cavities in bones, the largest of which is the antrum in the superior maxillary. A thin translucent plate of

bone intervenes between it and the socket. High up, it opens into the nose, and is lined throughout by mucous membrane. The antrum is large enough to hold a musket-ball, and instances are on record, in which bullets have lodged there for years. The frontal sinus, at the upper and inner part of the orbit, communicates freely with the superior meatus of the nose, through the infundibulum. The numerous air cells, in each mass of the ethmoid, are separated from the socket only by a thin plate of bone, the os planum. (Fig. 903.)

Tumors and accumulations of various kinds in these cavities, are likely to encroach upon the orbit, dislodge the eye, and cause exoph-

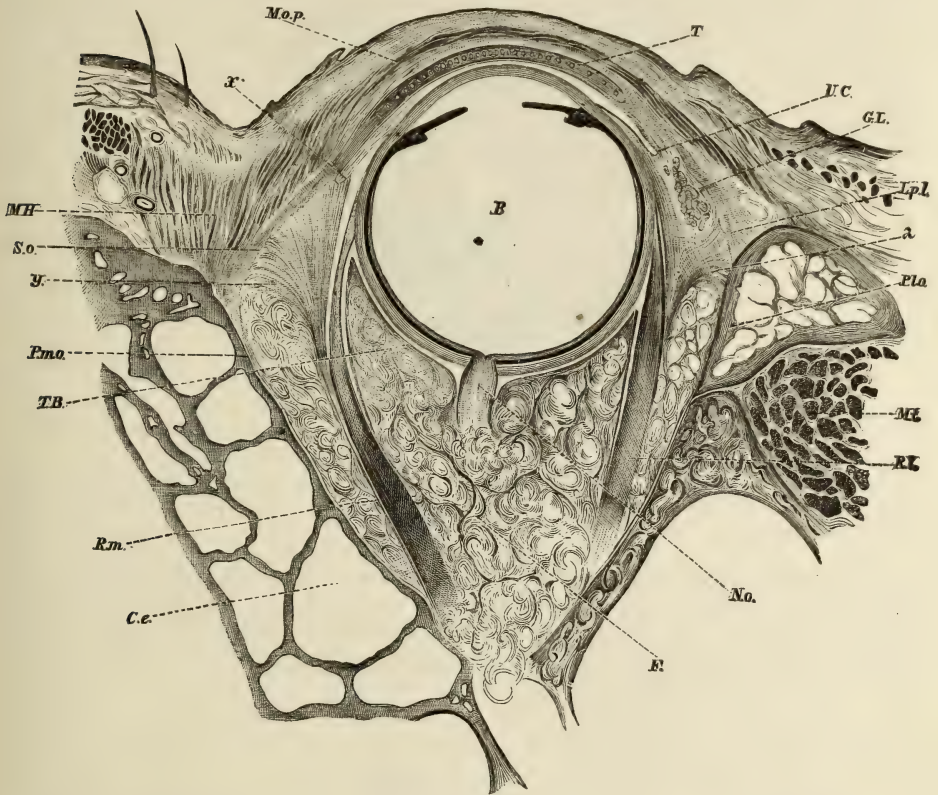
Fig. 903.



Frontal section of an adult skull through the middle of the orbits. *O.* Orbit; *N.* Naris; *A.m.* Antrum maxillare; *C.c.* Cranial cavity. (After Merkel.)

thalamus, diplopia, and other serious troubles. I have seen several cases of cyst in the ethmoid, that crowded the contents of the orbit, and had to be treated surgically, to save the eye. Cases of fistula of the frontal sinus, presenting above the tendo oculi, have been sent to me for fistula lachrymalis.

Fig. 304.



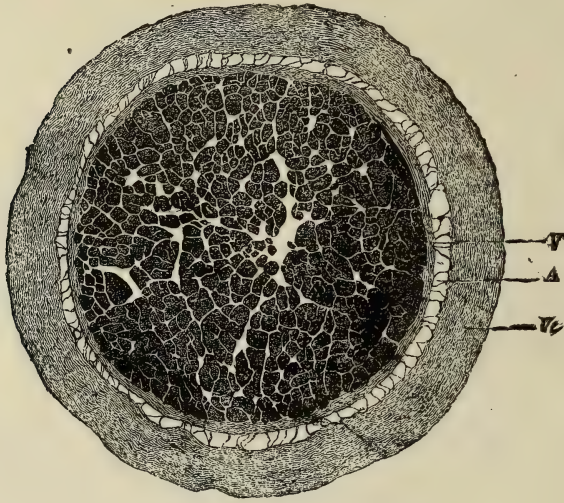
Horizontal section through the orbit of an adult male. *B.* Eyeball; *R.L.* External rectus muscle; *R.m.* Internal rectus; *F.* Orbital fat; *N.o.* Optic nerve; *T.B.* Capsule or fascia of Tenon; *L.p.l.* External palpebral ligament; *G.L.* Lachrymal gland; *S.o.* Orbital septum; *M.H.* Upper part of Horner's muscle (tensor tarsi); *U.c.* Reflexion of conjunctiva; *T.* Tarsal cartilage; *M.o.p.* Orbicularis palpebrarum muscle; *P.m.o.* Internal wall of orbit; *C.e.* Ethmoidal cells; *P.l.o.* External wall of orbit; *M.t.* Temporal muscle; *X.* Junction of capsule of sheath of external rectus. $\times 1.7$. (After Gerlach.)

The bony orbit lodges the eye, the optic nerve, the six rotatory muscles and their nerves, sensory nerves, numerous bloodvessels, and a large amount of cellulo-adipose tissue, which gives soft support to the eyeball. (Fig. 904.)

OPTIC NERVE.—The optic nerve, entering the orbit through the foramen opticum, and measuring about 4 mm. in diameter, runs forwards, in a tortuous manner, to the sclerotic, slightly below and inwards from the posterior pole of the eye, which it pierces in an opening 1.5 mm. in diameter. Its entire length, within the orbit, is 28 or 29 mm. The nerve is closely embraced by a neurilemma, which is continuous with the pia mater, and which sends numerous septa inwards, to divide the fibres into separate bundles. Through these

divisions, the nerve trunk is freely supplied with blood. (Fig. 905.) A firmer external sheath, derived from the dura mater at the optic foramen, envelops

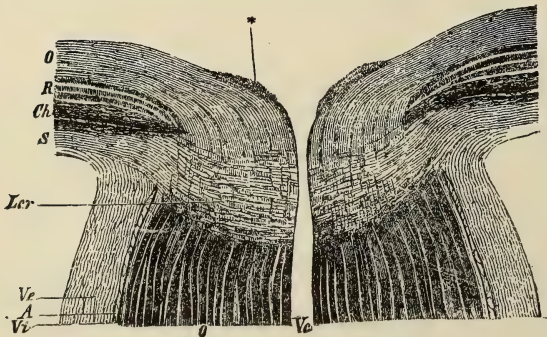
Fig. 905.



Transverse section of optic nerve a little in front of the entrance of the central vessels. *Vi*. Inner sheath or neurilemma; *Ve*. Outer sheath; *A*. Lymph-space between the two sheaths, a continuation of the arachnoideal space. (After Merkel.)

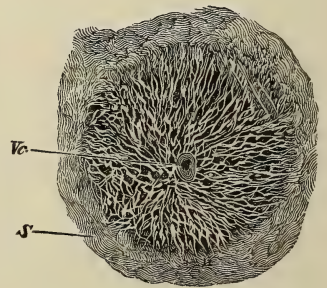
the nerve and neurilemma, and is laxly connected with the latter by delicate fibrous tissue. The two sheaths of the nerve, thus related, become more firmly united as they approach the sclera. On reaching the ball, the external sheath blends with the sclera, while the other is lost in the choroid.

Fig. 906.



Longitudinal section of the entrance of the optic nerve into the eyeball. *O*. Substance of optic nerve; *Vc*. Space for central vessels; *Vi*. Inner sheath or neurilemma; *Ve*. Outer sheath; *A*. Lymph-space between sheaths; *S*. Sclerotic coat; *Lcr*. Lamina cribrosa; *Ch*. Choroid; *R*. Retina. (After Merkel.)

Fig. 907.



Cross-section of optic nerve at point of passage through lamina cribrosa. *S*. Sclerotic; *Vc*. Cross-section of central vessels. (After Merkel.)

Constricted in passing through the sclera, the nerve changes its color from white to semitransparent gray, due to microscopic modifications in the nerve-

fibres as they lose their opaque sheaths. A third covering, between these two, very delicate, and in close relation to the outer or dural sheath, is now described. All the tunics of the brain are thus represented as continued in the sheath of the optic nerve. The intervaginal space, continuous with the subarachnoid spaces of the brain, is liable to serous infiltration from the brain, causing compression of the nerve-trunk. The constriction of the nerve in piercing the lamina cribrosa of the sclera, the sudden bending of the individual fibres as they pass into the retina, the canal in its axis for the central artery of the retina, as well as the opening in the choroid, are all well seen in the annexed cut. (Fig. 906.) Fig. 907 shows a transverse section of the optic nerve. The central artery of the retina pierces the sheath, about half an inch behind the eye, passes to the axis of the cord, and follows it till it enters the fundus and divides into its retinal expansions. The main trunks of the retinal arteries and veins enter and emerge from the centre of the optic papilla.

EYEBALL.—In form, the eyeball is very nearly a globe, whence its name. The antero-posterior diameter measures about 24 mm., the horizontal 23.5 mm., and the vertical 23 mm. (Merkel). Just back of the sclero-corneal junction, the globe is retracted as by a tight cord. (Fig. 908.) From the centre of the cornea to the deepest part of this constriction, the curvature is greater than that of the rest of the globe. The back half of the eye is much more uniform in curvature than the front. The shape and firmness of the ball are maintained by the outer tunic. This thick, dense coat is composed of two parts, continuous by their constituent elements, but differing greatly in their physical properties. The one, the sclera, is opaque like tendon; the other, the cornea, is clear like fine glass. The sclera forms a little more than four-fifths, and the cornea the rest, of this strong, investing coat. The *sclera* is thickest posteriorly, where it is pierced by the optic nerve, and reinforced by its outer sheath, measuring here 1 mm. Forwards it grows thinner, till again reinforced by the expanded and laterally blending tendons of the four recti muscles. The sclera is a dense, fibrous, white membrane, composed of fibres of connective tissue, rigidly interwoven in all directions, but running mostly at right angles to each other. The portion seen in front, is called the white of the eye. At the point of penetration of the optic nerve, the sclera is thin and pierced by numerous small holes for the passage of the bundles of optic nerve fibres. This weakened ring of sclera, which plays such an important part in glaucoma, is called the lamina cribrosa. It is that which gives the stippled appearance to the optic papilla, when seen with the aid of the ophthalmoscope. It is situated a trifle below the horizontal meridian, and 4 mm. to the nasal side of the posterior pole. Its diameter is about 1.5 mm.

Fig. 908.

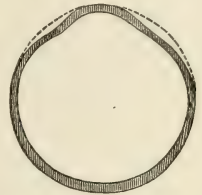


Diagram showing shape of eyeball. (After Merkel.)

In its entire outer surface, the sclera is embraced by the capsule of Tenon, to which it is loosely connected by elastic tissue, allowing of the greatest freedom of motion. The ball rotates in this capsule, much as the head of the femur moves in the acetabulum.

In front, the sclera encroaches somewhat on the *cornea*, especially above and below. For this reason the cornea appears oval horizontally, when viewed anteriorly, but circular when seen from behind. Near its inner surface, close in front of the iris and just behind the sclero-corneal junction, lies the circular, flattened canal called the sinus venosus, the canal of Schlemm, and, by Leber, the plexus ciliaris. Close in front of this venous

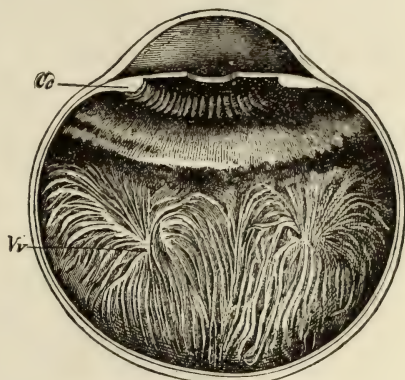
canal or canals, the opaque sclera is suddenly transformed into the clear cornea, the line of union being called the *limbus corneæ*, or the *sclero-corneal junction*. The horizontal diameter of the cornea, in front, measures 11.6 mm., while the vertical is 11 mm. The anterior surface of the cornea is an ellipsoid, the curvature in the vertical being slightly greater than in the horizontal meridian. This gives rise to a slight degree of normal astigmatism. In the central region, through which direct vision takes place, the anterior and posterior surfaces of the cornea are parallel, the thickness measuring 0.9 mm., while in the periphery it is 1.1 mm. thick. The most important physical properties of the cornea are its great transparency and firmness of texture. It is seldom ruptured by blunt force, the sclera yielding in preference, in a line parallel to and close behind the base of the cornea. In virtue of its epithelial covering, the free surface of the cornea is very polished, reflecting sharp but diminutive images. The conjunctival epithelium is continuous with that of the cornea. As on a basement, this smooth epithelial layer rests on the condensed corneal tissue, called usually Bowman's membrane. Posteriorly the cornea is lined by a "glass" lamella, the membrane of Descemet. Its free surface, washed by aqueous humor, is covered by a single layer of endothelial cells, which have an important bearing on the filtration of fluids through the cornea. The proper tissue making up the main thickness of the cornea, is contained between these two surface membranes, and is of a lamellated character, capable of being resolved into a greater or less number of layers, according to the delicacy of the manipulation. Each lamina is composed of vast numbers of fine elastic fibres, running parallel with each other. The layers are placed upon each other so that the fibres of one lamina will lie at right angles to those of the next. The numerous laminae are knit together by fibres passing more or less perpendicularly through them. The interspaces between the superimposed layers and their elements are filled with a transparent, gluey substance, in which are lodged the corneal cells, and through which pass the irregular canals that circulate transparent, nutritive fluid. The cornea, as a necessary condition of its great clearness, is non-vascular, only becoming visibly vascular in consequence of inflammation. The cornea, in the deeper layers of its epithelium and in its superficial laminae, is very freely supplied by a fine, beautiful network of sensory nerve filaments. Its common sensibility is due to this liberal supply from the fifth nerve. The *arcus senilis* of the cornea, which is seen in many old persons, and rarely in the young, is a fatty degeneration of its elements, in a narrow strip just within its base. The sclera gives solid attachment to the rotatory muscles which reach it by piercing obliquely the capsule of Tenon. The four straight muscles are fixed to the anterior, and the two oblique to the posterior hemisphere of the sclerotic.

Within, the sclera is lined by the *choroid* for about two-thirds of its extent. The two are loosely connected by elastic fibrillar tissue, covered with endothelium, and forming lymph spaces. The choroid is excessively vascular, forming a reservoir of nutritive material for all the inner organs of the globe. It contains, in addition to its exquisite vascularity, fine fibres of connective tissue, numerous cells filled with pigment granules, and many nerve fibres. The amount of pigment in the cells of the stroma varies from great abundance in dark races, to little in fair persons, and none in albinos.

Posteriorly, the choroid is pierced by the optic nerve, the opening corresponding with the optic papilla and the blind spot. The choroid was once considered the seat of visual impressions, and the *hole* in it was, of course, a sufficient explanation for the blind spot! If divided into two layers, the outer contains the large choroidal vessels (*vasa vorticosa*, etc.) and the inner, the beautiful *chorio-capillaris*. It is undoubtedly to this rich network of capillaries,

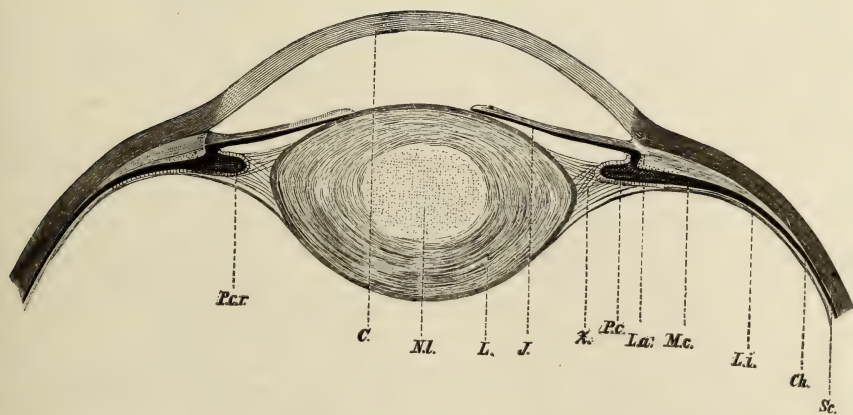
that the outer percipient elements of the retina (the rods and cones) look for their functional nutrition. Anteriorly, the choroid thickens into a wedge-shaped portion, called the *ciliary body*. From the ora serrata retinæ to within 1 mm. of the sclero-corneal junction, the thickness gradually increases, terminating in the ciliary processes, which surround the margin of the crystalline lens without touching it. The processes are about seventy in number, and make a beautiful picture when the eye is divided through the equator and they are looked at from behind. A good idea of them and of the vasa vorticiosa is obtained from Fig. 909. Continuous with the ciliary processes, and gaining from them part of its peripheral insertion, is the iris. Passing from the points of the ciliary processes to the margin of the lens, is the folded zone of Zinn, or suspensory ligament. The lens, agglutinated to the hyaloid fossa of the vitreous, and fastened by this ligament to the ciliary processes, makes a complete septum between the vitreous behind and the aqueous in front. (Fig. 910.)

Fig. 909.



Sagittal section of eyeball. $\times 3$. The retina has been removed with the pigment membrane, etc. Cc. Ciliary body; Vv. Venæ vorticosæ, visible through the inner layer of the choroid. (After Merkel.)

Fig. 910.

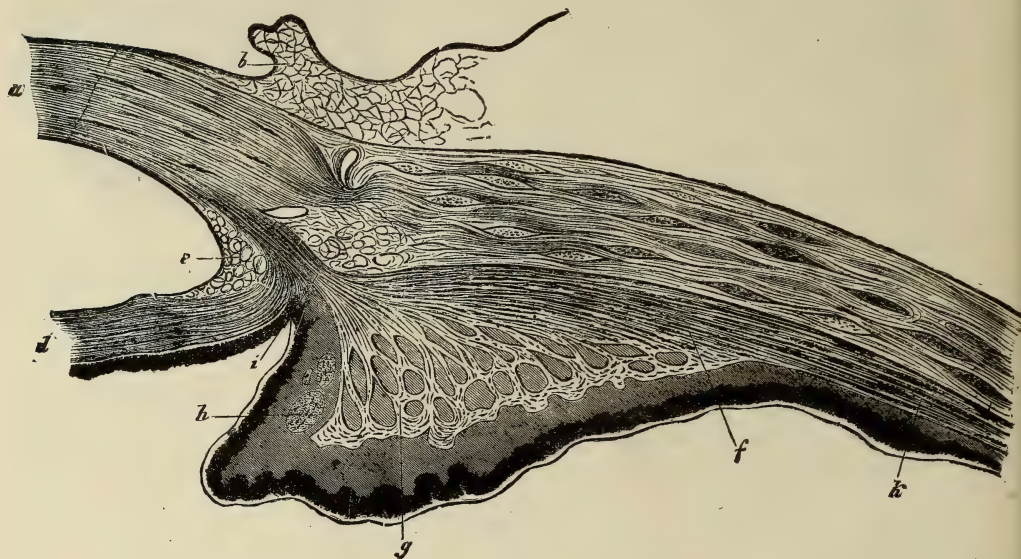


Meridional section of anterior half of human eyeball. Sc. Sclerotic; Ch. Choroid; L.i. Internal limiting membrane; M.c. Ciliary muscle; L.a. Annular ligament; P.c. Ciliary processes; Z. Ciliary zone; I. Iris; L. Lens; N.L. Nucleus of lens; C. Cornea; P.c.r. Ciliary portion of the retina. $\times 4$. (After Gerlach.)

On the outer surface of the ciliary body, next the sclera, lies a thickened, grayish ring, from 3 to 4 mm. wide—the *ciliary muscle*—by the action of which, on the lens, the eye is focused for distinct vision at different distances. This muscle takes its fixed attachment from the inner surface of the sclera, in a circular, tendinous ring, corresponding to the inner wall of the canal of Schlemm (Fig. 911). From this attachment it sends some tendinous fibres to the iris, and large numbers to the radiating and circular, non-striated fibres

of the ciliary muscle. This muscle, acting from the sclero-corneal junction, draws the choroid forwards and renders it tense, moving the ciliary processes likewise forwards, and a little towards the axis of vision. Thus the suspensory ligament is relaxed, and the anterior surface of the lens, which is

Fig. 911.



The ciliary muscle. *a* Cornea; *b*. Limbus corneæ; *c*. Sclerotic; *d*. Iris; *e*. Space of Fontana; *f*. Meridional portion of ciliary muscle; *g*, Radial portion of the same; *h*. Annular muscle of Müller; *i*. Anterior tendon of ciliary muscle; *k*. Posterior tendon of meridional portion of same. (After Iwanoff and Arnold.)

compressed in the quiescent state of the muscle, is allowed to grow more convex, in response to its natural elasticity. It is thus that the eye is accommodated for near vision, by an active process, producing *relaxation*.

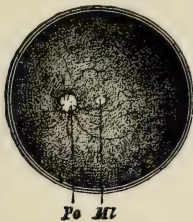
The active, muscular curtain, which regulates the amount of light admitted to the eye, the *iris*, is fastened at its periphery by fibres from the ligamentum annulare of the ciliary muscle, by bloodvessels passing directly between it and the choroid, and by the ligamentum pectinatum—bands of elastic fibres thrown over from the membrane of Descemet to the iris, at the outer margin of the anterior chamber. The spaces between these trabeculæ, and connecting with the aqueous chamber, allowing perhaps free filtration of the intraocular fluids, are now called Fontana's spaces.

In the surgical pathology of the eye, the ciliary region, including the outer rim of the anterior chamber, plays a very important part. The iris is a membranous septum, circular in form, passing across the eye close in front of the lens, from its attachment, 1 mm. behind the clear margin of the cornea, and pierced in its centre by the pupil. Its tissue is delicate, easily torn, and very sensitive, and both surfaces are bathed with the aqueous humor, in which it moves with perfect freedom. In its stroma are two antagonistic sets of muscular fibres. One set is arranged in a circular band around the pupil, on the posterior surface, and about 1 mm. wide, supplied with motor force by filaments from the third nerve. The other muscle passes from the entire periphery of the iris, in converging directions, to the sphincter pupillæ, with

which its fibres are interlaced. This is the dilator of the pupil, and it is endowed by filaments from the sympathetic nerve. The iris tissue is abundantly supplied with bloodvessels and pigment cells, the latter more exuberant on the posterior surface. There is likewise a generous distribution of nerve-fibres, sensory and motor, all the elements being united by connective tissue. The iris, in a narrow ring around the pupillary border, rests against the anterior lens capsule, over which it slides in the almost constant movements of contraction and dilatation of the pupil. The pupil moves in response to reflex impressions, made by light on the retina.

Lying immediately within the choroid, and extending from the optic nerve entrance to the ora serrata retinæ, is the nerve-membrane, the *retina*. It is a very soft, perishable structure, quite transparent, and hence invisible, except by the bloodvessels with which it is freely supplied. Ordinarily perfectly colorless, it becomes of a purplish-red by a sojourn in the dark. This color is soon dissipated when the eye is exposed to common light. Fascinating as may be the chemical theory of vision, it is by no means certain that actinic action has anything to do with this marvellous function. Three objects, all in or connected with the retina, are positively to be seen by ophthalmoscopic illumination: the optic disk, with its sharp margins and

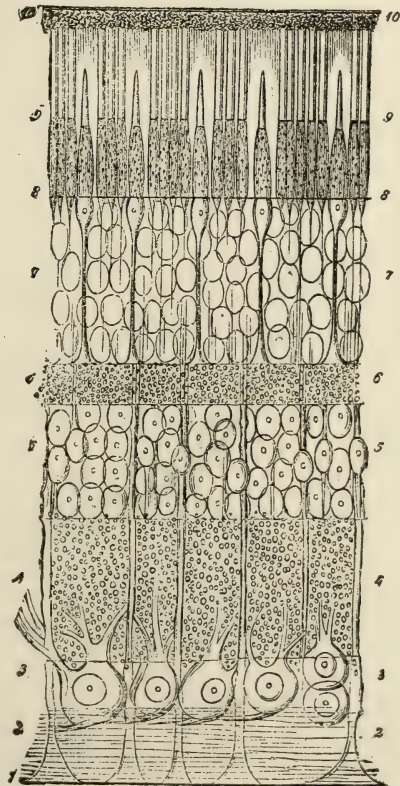
Fig. 912.



Equatorial section of eyeball, natural size, posterior segment. *Po.* Optic papilla; *Ml.* Macula lutea. (After Merkel.)

characteristic vessels; the *macula lutea*, in the direct line of vision; and the ramifications of the retinal vessels. The disk or papilla is of circular form, 1.4 mm. in diameter, light purplish-white in tint, and contrasting sharply with the deep-red color of the rest of the fundus of the eye. In its centre are seen the main trunks of the central artery and corresponding veins of the retina, radiating and ramifying in all directions, but more notably towards the inner, upper, and lower parts of that membrane. The arteries are easily distinguished by their lighter color and somewhat smaller size. About 4 mm. from the centre of the papilla, and outwards, is seen the macula lutea with its fovea centralis. This lies in the axis of direct vision, and is the most exquisite part of the retina. (Fig. 912.)

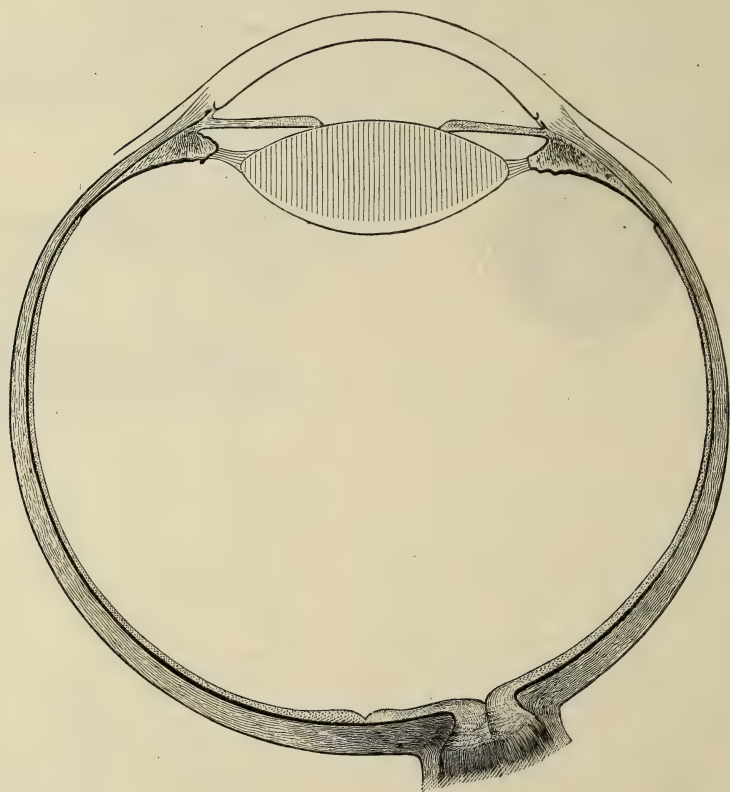
Fig. 913.



Diagrammatic section of the human retina, showing its ten layers. (After Schultze and Schwalbe.)

The conducting fibres of the optic nerve, estimated at 438,000, unfolding in the papilla, bend suddenly outwards and are lost in the retina, constituting its innermost layer, in which are distributed the arteries and veins. Studied in microscopic sections, there are ten distinct layers in the thickness of the retina. (Fig. 913.) The tenth of these, the pigment epithelium, formerly described as belonging to the choroid, and in which are buried the outer ends of the rods and cones, is now known to be an integral and very important part of the retina. The rods and cones standing perpendicularly in the outer layer of the retina, are the percipient elements; the inner layer is composed of nerve-fibres which are conductors; and the intermediate structures serve to connect these two essential elements. Filling and giving solidity to the globe of the eye, and with the cornea forming its refracting media, are the aqueous and vitreous humors with the crystalline lens between them. (Fig. 914.)

Fig. 914.



Diagrammatic horizontal section of the eye. (After Merkel.)

The space between the cornea and the lens is the *aqueous chamber*, divided by the iris into the anterior and posterior, communicating through the pupil. The depth of the anterior chamber is 3.6 mm. In active accommodation, the lens capsule, becoming more convex and carrying the iris forwards, diminishes slightly the depth of the chamber. It is now positively certain that the *lens*, acted on by the ciliary muscle, is the *instrument* of accommodation. As age progresses the lens hardens, responding less and less

to the efforts of this muscle, and the patient becomes presbyopic and has to use glasses for reading, except when myopic.

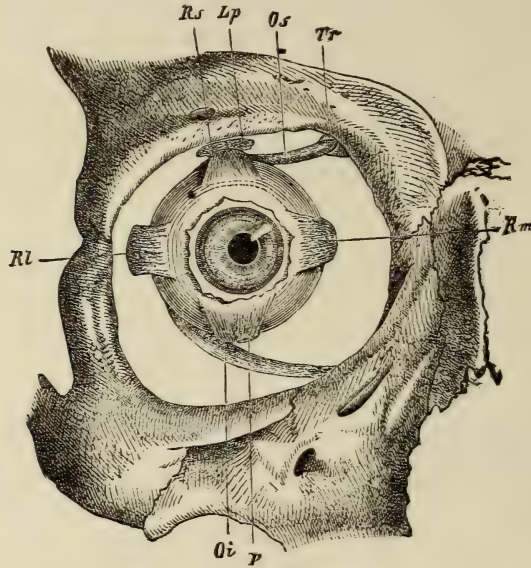
The popular notion that flattening of the cornea is the cause of presbyopia has no foundation. The lens is a double convex body, held in its position close behind the iris, by the suspensory ligament and adhesions of its posterior capsule with the hyaloid fossa. In young persons it is soft, elastic, and colorless; in advanced years it becomes of an amber color, and hard like a piece of dry cheese. The anterior surface of the lens is less convex than the posterior. The thickness of the lens in its axis is 3.7 mm., and its equatorial diameter is from 9 to 10 mm. The firmer, central part of the lens is called the nucleus, and the outer layers the cortical substance. It is composed of numerous layers like an onion, the layers being formed by individual, serrated lens-fibres. The lens is closely invested by a capsule, of which the anterior portion is thicker and more resistant than the posterior. It is structureless and perfectly clear, and resists chemical reagents in a remarkable way. The medium of connection between the lens and the capsule is a thin layer of cells from which the lens-fibres take their origin, and through which its nutrition is accomplished. How the lens is held in its position has been already stated.

Filling up all the interior of the eye, back of the lens, is the *vitreous humor*, or corpus vitreum. This is of the consistence of jelly, hangs together in a mass when lifted, and is absolutely transparent. Hence the difficulty in studying its structure, and the various views in regard to it, error being sometimes caused by the chemical reagents used in hardening it. Liquefaction of the vitreous takes place soon after death, and, in many pathological conditions, during life. In the extraction of cataract, a healthy vitreous greatly diminishes the risks of accident, and should be ascertained as certainly as possible. In the process of diseases of the choroid, especially, the vitreous is liable to become in part or entirely disorganized. In that case it is turbid, with floating corpuscles, and interferes with satisfactory ophthalmoscopic examination.

MUSCLES ATTACHED TO THE EYEBALL.—The eyeball, so balanced in the orbit as to yield to the least muscular force, is rotated in the various directions by six muscles. The four recti, originating by a common tendon at the optic foramen, passing directly forwards so as to embrace the globe and fasten themselves upon it, form two pairs. The superior and inferior oblique constitute the third pair. The favorable way in which the eye is pivoted in the socket, and acted on by these muscles, is well seen in Fig. 915. Of the four recti, the internal is the strongest and the superior the weakest. Before their firm insertion into the sclera, the four recti become tendinous, the width and situation of their insertions being easily seen in the cut. The flattened tendons, the relative distance of their insertions from the cornea, and the peculiar relations of the tendons to the capsule of Tenon, through which they must pass to reach the sclerotic, have been very critically studied since the introduction of tenotomy for the relief of squint. The most trustworthy measurements (Merkel) of their points of attachment from the cornea, are: for the rectus internus 6.5 mm., rectus externus 6.8 mm., rectus superior 8.0 mm., rectus inferior 7.2 mm. The width of the tendons varies from 7 mm. to 9 mm. These tendons, before their insertions, send numerous filaments of connective tissue to the sclera, and also from their edges, thus adding firmness and breadth to their proper tendinous attachments. The globe is embraced by the capsule of Tenon, which is loosely connected to the sclera, and in which the eye rotates. It blends with the conjunctiva, and ends near the margin of the cornea. Behind, it is connected with the ball at the seat of penetration of the ciliary nerves and vessels, not reaching quite

to the optic nerve. Coming forward through the cushion of orbital fat, the recti muscles pierce this capsule obliquely by their tendons, and are loosely connected with it. The fascia of these muscles is likewise pretty firmly

Fig. 915.



The eye in its normal situation in the orbit, seen from in front. *Lp.* Levator palpebrae superioris; *Rs, Ri, Ri,* *Rm.* Attachments of the straight muscles of the eyeball. *Tr.* Trochlea. *Os.* Tendon of the superior oblique muscle. *Oi.* Inferior oblique muscle. (After Merkel.)

connected to the outer surface of the capsule of Tenon, where they press upon it before passing through to reach the sclera. It is this arrangement that prevents a complete tenotomy from destroying all control of the muscle over the eye. It still rotates the eye through this indirect influence on the capsule and its insertion around the cornea.

The movements produced by the isolated or combined action of these muscles, are rotations around a fixed point in the axis of vision, 13.54 mm. behind the centre of the cornea, near the physical centre of the globe. In moving the eyes right or left, in the horizontal level, one muscle only in each eye is called into play. The external moves the cornea directly outwards, and the internal, inwards. In moving the cornea directly upwards, the superior rectus and inferior oblique combine in their action. In turning the cornea downwards, the inferior rectus and superior oblique work together. In all the oblique movements of the eyes, three muscles combine. In all movements *below* the horizontal level of the eyes, the superior oblique is brought into play. In all rotations *upwards*, the inferior oblique is active. The single action of the superior oblique rotates the cornea downwards and outwards, that of the inferior oblique upwards and outwards. The third nerve (oculo-motor) supplies the recti muscles (except the external), the inferior oblique, and the levator palpebrae superioris. The fourth (trochlearis) inspires the superior oblique, and the sixth the external rectus.

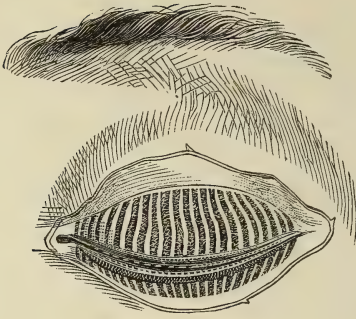
In no other part of the body do we so readily detect even slight muscular disturbances, as in the rotatory movements of the eyes. Derangements that elsewhere would never be noticed, are here painfully forced on the attention

by diplopia, or double vision. This is present no doubt in the beginning of all cases of strabismus, and is the most harassing and persistent symptom of muscular paralysis.

EYELIDS AND LACHRYMAL APPARATUS.—That the movements of the eye may meet with the least possible resistance from friction, the anterior half of the globe and the inner surface of the lids are lined by a smooth mucous membrane, constantly lubricated by its own secretions. To provide additional moisture, and keep the cornea constantly free from accumulations of the waste epithelium, the secretions of the *lachrymal gland* come into play. This gland lies in the pit near the upper and outer margin of the orbit, and pours its fluid through the excretory ducts on the eyeball. The surplus tears find their way over the globe, and are finally carried into the nose by the tear passages, the canaliculi, the lachrymal sac, and the nasal duct. The *conjunctiva* extends from the free edges of the lids, where it is continuous with the skin, back through the fornix to the globe, and thence forwards, over the sclera, to the margin of the cornea, the latter being covered by the continuous epithelium. It is divided, according to its distribution, into the tarsal portion; the reflected portion, or fornix; and the ocular portion that covers the sclera. The tarsal division is firmly united to the inner surfaces of the tarsi, above and below, and is dissected off with difficulty. The reflected portion is more loosely united to the structures below, and readily becomes infiltrated by inflammatory products collecting in, and especially underneath it. The ocular covering is very thin and transparent, and is also connected to the sclera very loosely. Inflammatory collections under it, so common and so alarming, are called chemosis. At the margin of the cornea, the conjunctiva, blended with the capsule of Tenon, is firmly united to the sclera. Hence, to effectually fix the eye for surgical operations, it must be seized as close to the cornea as possible. The free, smooth, epithelial covering of the conjunctiva, forms the surfaces that glide so easily and comfortably over each other in the movements of the eyes, and in winking. The conjunctiva, especially the strip lining the back portion of the tarsus, next the fornix, is traversed by many deep fissures which communicate freely, and into which the epithelium dips, giving it an uneven appearance. These fissures were formerly described as papillæ. The conjunctiva is supplied with bloodvessels, and parts are infiltrated with lymph cells, capable of enormous increase, and causing great swelling and hypertrophy in inflammation. It is likewise freely endowed with sensibility by distributions of the fifth pair. The different kinds of glands that open on the conjunctiva, along the free margin of the lids, on the limbus conjunctivæ, and in the fornix, properly belong to other structures of the lid.

The *eyelids* are movable, complicated structures, opening and closing in response to muscles, like shutters. Into the framework of each, to give it stiffness, enters a condensed fibrous structure of semilunar shape, called the tarsus. The tarsus of the upper lid is longer and broader than that of the lower. The thick, sharp-cut edges of the lid, along the anterior lip of which the eye-lashes are implanted, and on the posterior lip of which the Meibomian ducts are seen, is formed chiefly by the thick tarsus. Toward the upper edge, into which the levator palpebræ superioris is fastened, it grows quite thin. Imbedded in the thickness of the tarsus, perpendicular to its free margin, and belonging histologically to the skin, are the Meibomian glands, long tubes with acinous attachments, and opening in visible points along the inner lip next the conjunctiva. (Fig. 916.) The points in which the two lids unite are called commissures. The outer commissure is sharp, and the inner rounded out to receive the caruncula lachrymalis of the conjunctiva, behind which is a vertical, thickened fold of conjunctiva called the plica semilunaris. At the inner com-

Fig. 916.



The eyelids closed. The skin over both tarsal cartilages removed, so as to make the tarsal glands visible. (After Merkel.)

missure are also found the tear ducts for collecting and carrying off the superfluous tears to the nose. At the inner end of each tarsus are the openings of the canaliculi, one above and one below. These points, surrounded by some circularly disposed fibres of the orbicularis muscle, are called the puncta lachrymalia. The small canals leading from them into the lachrymal sac, are the canaliculi. They sometimes unite before reaching the sac, and at other times enter it separately. Lying in the lachrymal groove of the os unguis, traversed near its middle and supported by the tendo oculi of the orbicularis muscle, is the lachrymal sac, which passes by the nasal duct to the inferior meatus of the nose. In a healthy state the

Fig. 917.



Orbicularis muscle of the left eye, with the neighboring muscles. *Lm*. Median palpebral ligament; *EF*. Occipito-frontalis muscle; *Qls*. Quadratus labii superioris; *Z*. Zygomaticus. (After Merkel.)

puncta are held gently against the ball, and the tear passages are made to perform their function by the action of the orbicularis muscle. Through the puncta, the mucous lining of the eyelids is continuous with that of the nose and throat. Lying on the anterior surface of the eyelids, between the skin and the tarsi, and extending over the prominent base of the orbit, is the sphincter of the eyelids, the orbicularis muscle. Beginning from the lower edge of the tendo oculi and the adjacent bone, it sweeps around the outer commissure and comes back to be inserted into the upper edge of the same tendon. It is divided into the palpebral portion, lying on the tarsi and exclusively used in winking, and the orbital, called into voluntary play when the eyes are firmly closed. This muscle is supplied by the portio dura of the seventh pair, and, with its relations, is beautifully seen in Fig. 917. Implanted deeply along the anterior lip of the free margin of the lid, with their bulbs between the orbicularis fibres and the surface of the tarsus, are the ciliæ or eye-lashes. Covering the entire muscle and continuous with the skin of the face, is the thin cutaneous covering of the eyelids, with its loose subcutaneous tissue. The upper eyelid is provided with a muscle, the levator, to lift it, while the lower subsides over the projecting globe in response to gravitation, when the orbicularis is relaxed.

OPTICAL DEFECTS DEPENDENT UPON ANATOMICAL PECULIARITIES OF THE EYE.—By actual measurement the eye varies in size very much, in different persons. The optically perfect eye measures 24 mm. in the antero-posterior diameter, and is called *emmetropic* or normal. In such an eye the retina lies in the focus for parallel rays. Distant objects, from which such rays only come, are sharply imaged upon the retina. By distant, we mean from 18 feet off to infinitely far, as the stars. If the eye is smaller than this ideal standard, measuring, for instance, 20 mm. from cornea to retina, it is called *hyperopic*. In that case parallel rays, undergoing the same refraction by the cornea and lens, will strike the retina *before* intersecting, and the image will not be sharp. Hence vision of remote objects is imperfect, as long as no voluntary muscular effort of accommodation is added. Theoretically, such an eye could only unite *convergent* rays upon the retina; but in nature no objects exist that send off such rays, because none are *beyond* an infinite distance. Practically, then, such eyes are always on a strain, making active efforts of accommodation for all distances. They are never at rest except in sleep. By an *emmetropic* eye, remote objects are seen with perfect definition without any accommodative muscular action. Hence the ciliary muscle is at absolute rest, except in reading and near work. This difference accounts for the tired and fatigued feeling of hyperopic eyes, which distresses them and gives the physician so much trouble and anxiety. When applied to close work especially, they tire easily, and are called weak or asthenopic. The pain and fatigue result from strain of the ciliary muscle, and the trouble is called accommodative asthenopia. It is in hyperopes that we so often find convergent strabismus. There is still another deviation from the *emmetropic* form, and that is the *myopic* or near-sighted eye. In such the distance from cornea to retina is increased, so that parallel rays intersect *before* reaching the nerve membrane. The axis of vision measures 25, 30, or even more, millimetres. The farthest point of distinct vision, instead of being at an infinite, is at a finite distance. It comes nearer and nearer, as the degree of myopia increases. Beyond the far point, all is dim, the farther the worse. Such eyes can only get sharp images of distant objects by the use of concave lenses. All persons who see distant objects *better* with convex lenses, *must* be hyperopic. Those whose remote vision is cleared by concave glasses, *may* be myopic. Myopia occurs rarely in old people, and then generally with incipient cataract. If

the myopia reaches in them a high degree, they lay aside their spectacles for reading and boast of second sight. Just in proportion as they gain in reading without glasses, they lose in distinctness of sight for distance, and must use concaves. Myopia is an *acquired disease*. Hyperopia is a *congenital defect*. In myopia the eyeball is enlarged and strikingly prominent. Around the posterior pole the sclera and other tunics bulge backwards, giving that part of the globe an egg shape. Diagnosis of the refraction of the eye is not always easy. In expert hands, the most direct and independent means of ascertaining the refraction is the ophthalmoscope. But accuracy in this means of diagnosis involves not only a long experience, but an absolute knowledge of the refraction of the observer's own eye. If the eye of the examiner and that of the examined are both emmetropic, then an absolutely sharp image of the fine vessels in the direct fundus will be obtained. To do this and get a large magnifying power, the eye carrying the ophthalmoscope must approach almost to contact with that inspected. This is the examination in the erect image. If the examiner's eye is myopic, or hyperopic, it must be rendered emmetropic by the proper lens in the eye-clip.

If no distinct image of the fine fundus is obtainable, the accommodation of the examiner and examined being relaxed, then there is *either* hyperopia or myopia. If a convex lens added to the clip makes the details clear, there is hyperopia. If a concave is required, it must be myopia. In the family of mydriatics we find a valuable aid in ophthalmoscopic diagnosis. When atropine, hyosciamine, or duboisia in strong solution, is applied to the eye, it soon dilates the pupil and paralyzes the ciliary muscle. By this means we eliminate a troublesome factor, the accommodation, and have the eye at rest. Moreover, when the accommodation is relaxed in this way, it renders the use of test-glasses in the diagnosis very easy, simple, and sure. Atropinize a myope, and it will affect his distant vision little or none. It was bad before, and is so still. Do the same for an emmetrope, and his remote vision will not be seriously changed. It was good before, and is so still. The only change is, that he can no longer read print without the aid of a strong convex lens. His power of varying the refraction, by voluntary contraction of the ciliary muscle, is temporarily lost. Subject a hyperope to the thorough action of atropine, and his sight for distance will be reduced, more or less seriously, according to the degree of hyperopia. Then, if a convex glass brings it up to what it was before, hyperopia undoubtedly exists, and the *degree* is measured by the strength of the glass required to give perfect sight for distance. This is the most certain means of diagnosis, and in all doubtful cases should be resorted to in order to confirm the diagnosis by other methods. One serious objection to the use of the ordinary salts of atropia for this purpose, as well as for facilitating ophthalmoscopic examinations, is the long time (sometimes a week or more) that the effects last. Happily, the homatropine relaxes the ciliary muscle quickly and thoroughly, and its effect soon passes away, generally inside of 24 hours. To do this thoroughly it must be strong (8 grains to the ounce), and dropped in freely every 20 or 30 minutes, for two or three times. No constitutional effects are noticed, as in the similar use of atropine or duboisia. Duboisia is quite as certain in its effects, and more transient than atropine. Its influence does not pass off as soon as that of homatropine, and it is very liable to produce serious constitutional symptoms. I now use homatropine almost exclusively for testing refraction and for ophthalmoscopic examinations; in the latter, applying a much weaker preparation. Hyperopia may be entirely latent, or altogether manifest. In the former case, it is neutralized by the strong activity of the ciliary muscles, as in children and young people. In the latter, nearly always in persons in advanced life, the lens becomes so hardened that the ciliary muscle can no longer over-

come the hyperopia. When the hyperopia is all manifest, the simple use of the mirror and of the test-glasses is all that is required. In that condition hyperopes are compelled to use glasses all the time, or else to see very imperfectly. They need one pair to neutralize the hyperopia and to walk with, and another, stronger pair to read with. Young hyperopes, whose eyes have been trained to tolerate the glasses they need, can use the same glasses for walking and reading. Their accommodation makes up for the increased refraction needed in reading. Another anomaly of refraction is often found, alone, or in connection with hyperopia or myopia. It is due to differences of curvature in the different meridians of the cornea, and is called *astigmatism*. As in other anomalies, the refraction may be defective or excessive, constituting hyperopic or myopic astigmatism. Astigmatism in high degrees impairs the sight much more than simple hyperopia or myopia, as the effect is very imperfectly corrected by accommodation. The diagnostic aids are the ophthalmoscope, mydriatics, and tests with glasses of cylindrical surface, convex and concave. The usual test-types, as in trying for hyperopia and myopia, a system of lines radiating from a centre, and other devices, are resorted to in order to facilitate accuracy of diagnosis. My space will not allow details in this interesting department of physiological optics.

DIAGNOSIS OF OCULAR AFFECTIONS WITHOUT THE USE OF THE OPHTHALMOSCOPE.

Medical men often talk flippantly about the use of the ophthalmoscope, flourishing the instrument before the dazed eyes of their patients, seeing *nothing* and not even knowing how to interpret *that*. It is kept as one of many professional trappings, and has its reward. As a blow-bugle, in the recruiting office of rival medical schools, it has an important place, but how few students ever look through it with discrimination! A few weeks of special instruction by a competent teacher will alone enable the student to *begin* the intelligent employment of it in diagnosis. But daily and persevering use of this or any other instrument of precision, is required to give it serious importance. I do not exaggerate its difficulties, or disparage its faithful employment. It is invaluable in the differential diagnosis of deep-seated lesions of the eye, as well as in the study of disease seated elsewhere. It would be as rational to study astronomy by the aid of a spy-glass when we can use a telescope, as to discard the ophthalmoscope in the critical study of fundamental diseases of the eye. But I simply state the above well-known facts, in order to urge the importance of other and simpler means of diagnosis, which are too much neglected by the general practitioner. I want to show how many valuable things he can find out by the aid of the spy-glass!

Cataract, when bad enough to seriously trouble sight, can be perfectly made out without the ophthalmoscope. With the pupil dilated and oblique illumination, no doubt need exist. Then the functional tests will show whether the visual defect is in rational proportion to the changes seen in the lens. Is the cataract mature, and the propriety of an operation asked? Functional interrogation of the retina as to acuteness of perception, and the visual field, is easily made and satisfactory. *Glaucoma*, frequent in senile subjects, may be fatally mistaken for cataract. And yet no very great tact is required to settle the differentiation without the use of the eye mirror. The absence of definable opacities in the lens; careful and repeated tests of tension; the general outward appearance of the eye, including the episcleral circulation; the size of the pupil, its activity and the texture of the iris; and above all, trials of visual acuity and the integrity of the field, will settle the question. Simple cataract runs its entire course without pain. *Glaucoma*

seldom does. Indeed, in the worst cases of acute glaucoma, the vitreous is so turbid and the cornea so dull, that no ophthalmoscopic inspection of the fundus is possible. Yet our diagnosis need be none the less positive.

Iritis in all forms and degrees can be made out, beyond a doubt, by ordinary scrutiny, aided by atropine and oblique illumination. If cyclitis, or choroiditis, or optic neuritis exist with it, the eye is usually too tender to light, even if the vitreous be clear, to admit of a protracted use of the reflector. The functional tests of vision, in a moderate light, will give a reasonable clue to the integrity of the fundus. If the defect of sight be out of proportion to the changes in the iris, pupil, and aqueous humor, we infer a deep-seated complication. Increased tension in such a case means *glaucoma*, and the reverse indicates *cyclitis*.

Of course, all alterations of transparency and shape in the *cornea* are perfectly ascertained by the usual means, oblique illumination and functional tests of vision. There is no excuse for mistaken diagnosis between these and cataract, and the ophthalmoscope *alone* is very liable to lead to error.

How many hundreds of patients are referred to specialists for "disease of the optic nerve," where the fundus is absolutely sound, and where a rational diagnosis might and should have been made without the mirror! These are cases of *asthenopia*, with very characteristic symptoms. Painful fatigue of eyes, blurring of vision and difficulty in reading after a few moments' close application, heaviness of the lids and frequent desire to close and rub them, are the most constant burden of complaint. The sufferings are always aggravated by persistent, close use of the eyes, sedentary habits, nervous temperament, anæmia, and the multiform manifestations of hysteria. People thus affected are usually still young in years, but old in complaints. In females, it is very apt to be an accompaniment of uterine disturbances, and increased by causes of debility. The patient has been a victim of these painful troubles and forebodings, perhaps, for many years, and still has perfect sight when briefly tried. For a few seconds he reads the finest print, and has perfect definition for distance, but then the sight wavers. How can a serious lesion of the optic nerve, or of any other important part of the eye, persist so long, give so much pain and worry, and still leave the sight perfect? Real diseases of the optic nerve, in their entire course to total blindness, are attended by little or no pain. This is true of many of the worst diseases of the retina and the choroid. Let us look into some of these cases by common aids, and guided by a modicum of mother wit. Outwardly the eyes look healthy. Tested separately, the sight of the two eyes is equal and perfect for distance. The patient reads the smallest diamond type distinctly for a few moments. Then the letters mix, blur, and the eyes become painful. So he desists, and closes and rubs his eyes. There is probably some anomaly of refraction, producing fatigue of accommodation. Convex glasses, one dioptric (37 inches focus) clear the print and enable him to read longer without fatigue and glimmering. He cannot be myopic, but may be, probably is, hyperopic. Further investigation must now be made to settle that question. But of this you may be certain. The patient has no disease of the optic nerve, nor other affection that is going to lead to blindness. You can set his mind at rest on that point. If distant vision is imperfect, and near work quite clear, he may be myopic, and the necessary investigation should be made. If in any case, the sight of the two eyes is materially different, they must be examined separately, and the vision equalized if possible. If the vision is very bad in one, and perfect or nearly so in the other, then there may have been a congenital difference, or one of long standing, but just now found out. If both eyes are bad for all distances, then there may be a marked astigmatism or other trouble requiring the ophthalmoscope and means of investigation not at

your command. Whether it is a disease requiring treatment, or an optical defect demanding assistance from glasses, can only be settled by an expert examination. These asthenopic troubles that give the surgeon and the patient so much anxiety, depending as they do upon so many different causes, cannot be fully investigated or satisfactorily treated by the general surgeon.

Patients sometimes apply for advice about the alleged sudden failure of the sight in one eye. It has usually been discovered by the merest accident. The patient insists that he retired with two good eyes, and arose with one blind. How do you know that the patient is mistaken? If he has a matured cataract, or confirmed glaucoma, or old alterations of the cornea, none of these could have developed in so short a time. If there is strabismus confined to the defective eye, it cannot be of sudden origin. If the bad sight dates from childhood, or has come on very slowly, without pain, inflammation, or any unusual subjective symptom, it often passes unnoticed, till by some mere accident the patient is led to try the two eyes separately. If some confusion of vision, pain, or other uncommon worriment, such as flashes of light, glimmering, etc., have prompted him to the test of the two eyes, the difficulty is probably recent, and needs immediate intelligent attention. The previous history and habits of the patient as to shooting, and with which eye and what success, may also assist in clearing up the date of the difficulty. Has the eye ever been injured, and, if so, in what way and when? Has he ever used an opera glass with satisfaction? Without binocular vision that instrument is of little benefit. If the defect is very old, particularly if congenital, the ophthalmoscope, even in expert hands, is often simply negative in its findings. But when the lesion is serious and of recent date, it is often quite possible to make a fair diagnosis without the instrument. Suppose the patient to have had good eyes till quite lately. All at once he sees flashes of light, glimmering, trembling in the air like heat, and confusion of sight. He tries separately, and finds which eye is at fault. These troubles continue, with variations, for a few days. Then he discovers a dark curtain drawing in front of the eye. It passes across from one side to the other, cutting off all sight except perhaps in one oblique direction. With this significant description, you ask him to close the eye gently. You place the two index fingers on the ball and find its tension much reduced. The fatal diagnosis is *detachment of the retina*. If the patient has long been very near-sighted, this conclusion is greatly strengthened.

Again, there may have been great and sudden failure in one eye, perhaps without any premonitions, or these may have been very brief. The patient is advanced in years, has often suffered from rheumatism, and actually has organic lesion of the heart. The arteries feel hard to the finger, indicative of atheromatous degeneration. While coughing, lifting, straining at stool, in a violent fit of anger, or even without any special provocation, a large, red, ragged cloud comes before the eye. Here is a case of *hemorrhage into the vitreous*, from bursting of an intra-ocular vessel, a very serious affair for the eye, and still more grave as a prophetic indication of a similar accident to the brain. Spontaneous rupture, even of a subconjunctival vessel producing a blood-shot eye, is of no consequence in itself, except as it takes place in advanced years; and then it means brittle arteries, and danger to the brain or other vital organ.

Once more, you are consulted by a woman advanced in pregnancy. More or less rapid failure of sight in one or both eyes has brought her to you. You find vision generally impaired, especially in the direct line, by a central cloud or scotoma. Some pain and photopsia have been felt and seen, but outwardly the eyes appear normal. You suspect *Bright's disease*, and an analysis of the urine confirms your suspicion. The patient has albuminuric

retinitis, with changes so peculiar and characteristic, when seen with the ophthalmoscope, that the diagnosis of renal disease can be made from them alone. Still, we can be reasonably certain of the true lesion without using the ophthalmoscope. These eye symptoms, in a case of pregnancy, should lead us to expect puerperal convulsions before or at confinement.

Again, a patient with perhaps a syphilitic or rheumatic history, complains of double vision. This may or may not have followed headaches and other evidences of brain disturbance. It may have come from a current of air, or from no appreciable cause. He is giddy and uncertain in his gait. The moment one eye is shut, the diplopia ceases, and he sees without confusion. In closing one eye and walking across the room, his head swims and he staggers. Let him now shut that eye and walk with the other open. He feels secure and steady. He has *paralysis* of some one of the six *rotatory muscles*, and the *lame* eye is the one which he cannot walk with. Further investigation will differentiate the implicated muscle.

Another patient, a youth, has had excruciating attacks of headache, accompanied by vomiting. These paroxysms have lasted for months. They come suddenly, even when he is eating his dinner, and quickly he vomits his food and is relieved. He may eat again at once. This is causeless vomiting, not preceded by protracted nausea, but by violent pain in the head. At length dimness of vision begins in both eyes. The pupils are dilated, and there is a vague stare in the expression. This is a case of double *optic neuritis* from central brain lesion, probably a *tumor*. Of course the prognosis is very grave, both for sight and for life.

A child is brought, with supposed cataract in one eye. Your attention is attracted at once to a peculiar, yellowish, copper-colored reflex from the pupil. You see that it is too deep in the eye for cataract, and that it has not the color of an opaque lens. Otherwise the eye looks well. There is no pain as yet, and the little victim perhaps still sees somewhat with it. Diagnosis: *glioma*, or rather *sarcoma*, of the retina; and prognosis: death in a few months.

A person more advanced in years, has complained at intervals, for a long time, of pain, injection of the eye, and failing sight. At first he detects a circumscribed defect of vision in a certain limited portion of the field. Slowly the blind region enlarges, and the pain increases in frequency and severity till, at last, the blind eye is intensely painful all the time. Tension is increased; ciliary injection is marked; and large, tortuous, and inosculating vessels are seen in loops around the cornea. The pupil is excessively dilated; the anterior chamber very shallow; the iris discolored and its tissue greatly atrophied. This is probably a case of secondary glaucoma coming from a sarcoma or other *tumor of the choroid*. A similar growth in the *ciliary body* would be seen distinctly behind one edge of the lens, pushing it and the iris forwards.

A female, up in years and probably unmarried, consults you for excessive nervousness. Her eyes are protruded. Her expression is anxious. She gets scared and "flies all to pieces" at nothing. Her pulse runs from 120 to 140, feeble and irregular. There is more or less enlargement of the thyroid gland. These peculiar troubles vary in intensity, as they are influenced by mental or bodily disturbance, but her condition at all times is pitiable. This is a case of *Graves's* or *Basedow's disease*. It sometimes, but rarely, attacks men. Exophthalmus, as a common symptom of tumors of the orbit, can hardly be confounded with exophthalmic goitre, when we remember that the former very seldom affects both eyes, and that the latter always does, though perhaps in different degrees. Then the peculiar combination of the three leading diagnostic symptoms of Basedow's disease—

the exophthalmus, the goitre, and the nervous palpitation of the heart—makes mistakes impossible.

Pulsating exophthalmus is rarely seen on both sides; is always of traumatic origin; and is distinguished by the striking pulsation and bruit over the region of the orbit. Its pathology is found to be rupture of the internal carotid into the cavernous sinus of the brain, and nothing but ligation of the carotid can relieve it. Many years ago I reported a case caused by the passage of a cart wheel over a man's head, where both carotids had to be tied before the symptoms could be relieved. How often do we diagnose *locomotor ataxia* by the extreme and persistent contraction of the pupils. Such pupils do not change in size under varying degrees of light, but contract instantly when the patient looks at and reads fine print, or accommodates for any small, near object. I recall a case in which the patient was first treated for diplopia, resulting from paralysis of the external rectus of one eye. From this he completely recovered in about a year. He consulted me again for slowly failing sight. This was at least two years after his first recovery. I then detected this peculiar smallness of the pupils, and beginning gray atrophy of the right optic nerve. The myosis persists to this day, notwithstanding total blindness in both eyes from optic atrophy.

A knowledge of the semi-decussation of the fibres of the optic nerves in the chiasm, and of their peculiar distribution in the retinae, often enables us to fix the seat of a tumor at the base of the brain. Double optic neuritis generally means brain lesion, but does not locate it. *Hemiopia*, an extinction of vision in one-half the field, the dividing line being vertical—especially when it affects both eyes—may be a means of determining the seat of the lesion. For instance, darkness in the right half of the field in both eyes, means lesion of the left tractus opticus at the base of the brain, and *vice versa*. Blindness in both outer halves of the field (resulting from paralysis of the inner half of each retina) points to tumor of the pineal gland or the infundibulum, involving the posterior part of the optic chiasm. Extinction of both inner halves of the field, a rare occurrence, has been rationally explained, by Dr. Knapp, as indicating an atheromatous degeneration of the coats of the arteries in the circle of Willis. Other symptoms about the eyes help to fix the seat of cerebral troubles, but I cite these to show how much precision may be gained by observing the rational symptoms without the use of the ophthalmoscope. Indeed, in these cases, the instrument may be of no use whatever, as its findings are often negative. [See page 679.]

INJURIES AND DISEASES OF THE ORBIT.

INJURIES OF THE ORBIT.—All serious life must be wrought out in the face of foes. Scars and mars of the face mean courage; wounds in the rear tell the sad tale of retreat and mortification. The eyes were planted in the face, to look ahead and insure progress. The motto of true manhood is onward and upward. It is not a mere question of animal existence, and the survival of the fittest. Fight we must, to live. But true nobility prompts to the divine art of healing, and of helping the weak. For these, and still higher reasons, wounds of the face and eyes are far more frequent and important than injuries of the occiput and podex. The jewel of the face and light of the soul, is the eye. Its precious safety is guaranteed by firm and prominent bony protections, and the delicacy with which the ball is pivoted in the socket. Its round form and easy rotation save it often from rupture and injuries that would otherwise destroy it. The application of blunt force is warded off by the bones. Penetrating weapons, unless very direct, pass the

unharmful globe and enter the cavity. Contusions of the face are very frequent, but not often serious. A black eye is the result of such a contusion against the bony projections. Except when the violence is great, the concussion is not injurious either to the eye or to the brain. In direct blows on the eye, and in severe, indirect concussion, both may be damaged. Severe contusions, in addition to the bloody infiltration, are liable to be followed by inflammation and abscess. In predisposed subjects, or in times of epidemics, erysipelas with its alarming consequences may result. Orbital abscess, and loss of the eye, or even of life, is in that case to be apprehended. Periostitis and protracted trouble with the bones, are a rare sequel. Great depression, vomiting, and other evidences of cerebral disturbance, add gravity to the prognosis, and demand immediate attention. Contusions of the face and eyes are to be treated as they are elsewhere, never forgetting, however, the probability of erysipelas and abscesses supervening.

ORBITAL ABSCESSSES should be detected and opened as quickly as possible. As a rule, the pointing-place of an abscess is the best place to open it. But pus-collections in the eyelids, or orbit, require special care. The incision should be parallel to, and as far as practicable from, the free margin of the lid. If the matter comes from the orbit, make the opening close to the edge, so that the cicatrix may not evert the lid. When the time and symptoms indicate a deep collection, an early exploratory puncture ought to be made, avoiding the eye and other important organs. If required, a free incision to the bone may be practised, and the exploration thence continued. If the reaction is erysipelatous, constitutional supporting treatment must be pushed from the start. Of course, warm fomentations, poultices, and other local treatment have their value. Abscesses in the orbit are rare, except after wounds and erysipelas. But I have seen them in parturition, in low forms of fever, and as an evidence of pyemia. The fistulous tract is usually very long in healing, and then is almost sure to end in an indrawn adhesion to the bone. Orbital abscess is very apt to result in total blindness, even when the integrity of the globe is preserved. The inflammation directly invades and disorganizes the optic nerve, and white atrophy of the papilla follows. The danger to the sight is particularly great in facial erysipelas. In penetrating wounds of the orbit, even with the presence of a foreign body, the sight sometimes escapes marvellously. In others the optic nerve may be directly severed or injured, and loss of vision, without any violent reaction, is present. I have seen this in several instances. Optic neuritis and atrophy, or the latter alone, have followed.

The *symptoms* of orbital cellulitis and suppuration, are pain, swelling, protrusion and fixation of the eye, and, generally, marked constitutional disturbance. These go on increasing in intensity, till fluctuation and pointing are detected. Even after free evacuation of the pus, the suffering from pressure within the unyielding orbit is apt to continue for several days. Vigilance and early incisions, in such collections, may save sight, deformity, and long, severe suffering. Recovery after these abscesses is always tedious, and the ball retreats to its natural position very gradually. If the bones are deeply cut or fractured at the same time, slower healing and suddenly fatal developments may be witnessed. Clean cuts of the face and eyelids heal promptly when properly adjusted. Extreme pains should be taken, by using deep, firm sutures, to so adjust wounds of the lids that the cut tarsus may not be notched or distorted. Healing by first intention is of the first importance. In view of the gravity of orbital cellulitis and abscess, treatment must be prompt and energetic. In most cases sight will be lost, and in the severest forms, the cornea sloughs and the globe atrophies. The starting point and

nature of the reaction must be kept in view, in the rational treatment. Perfect quiet, warm poultices, often changed, anodynes, tonics, etc., inwardly, are the safest remedies. When the time comes for making incisions, they must be resorted to boldly, but not blindly. If erysipelas has extended to the orbit, the same local treatment and suitable internal remedies must be tried. If a penetrating wound is the starting point, the track must be dilated by means of grooved director and bistoury. Should the presence of a foreign body in the cavity be detected, it should be removed as quickly as possible. If caries of the bony orbit, or periosteal abscess, is at the bottom of the process, the chief attention is to be directed to that cause. The origin of this form of abscess is usually syphilitic, and the progress is very slow. The history, and a close observation of the course of the disease, will establish the diagnosis and direct the therapeutics. Evidences of dead and detached bone must be watched for with a view to its prompt removal. Deformity, in such a case, is inevitable. I introduce the following illustrative cases:—

I was consulted by an elderly lady, in very feeble health, for total blindness of both eyes. She had lost the sight some months before, during an attack of erysipelas of the face. There had been great protrusion of the eyes, and a discharge of matter through the lids, leaving retracted cicatrices. By inspection with the ophthalmoscope, I found the optic papilla in either eye very white, the vessels small, the margins ragged, and the surrounding retina hazy, showing the previous existence of neuro-retinitis. Facial erysipelas, extending to the cellulo-adipose tissue in the orbits, had destroyed the sight of both eyes.

As showing the danger to sight in spontaneous orbital cellulitis and abscess, I give the points of a case that occurred during the war:—

A man of 50 years sent for me in January, 1864, for severe swelling of the right eye. According to the patient's own account, he had been attacked with erysipelas of the face, in the course of which the inflammatory exophthalmus had made its appearance. From careful examination into the history of the attack, and an inspection of the face, I was convinced that the man had been seized with spontaneous inflammation and supuration of the cellular tissue of the orbit, and that the swelling of the face and lids was but symptomatic of the orbital abscess. The globe was protruded directly forward and entirely immovable; the pupil was dilated and fixed, and all perception of light had vanished. The slightest pressure of the eye backwards or against the orbit produced excessive pain. Fluctuation was detected at the upper and inner, as well as at the lower and outer part of the orbit. Free incisions were made and pus escaped from both points. The patient recovered in a few weeks, but the eye was completely amaurotic. There was abundant exudation in the optic papilla and surrounding retina and choroid. Some weeks afterwards, atrophy of the papilla appeared.

A woman of 28 years was attacked two weeks after confinement by severe pain behind the right eye, with rapid swelling and loss of sight. When I saw her, a week after, I found the eye much protruded and immovable; enormous chemosis and swelling of the eyelids; almost complete insensibility of the cornea, with slight haziness; discoloration of the iris; pupil moderately large, but filled with lymph; no perception of light; severe pain on pressing the globe backwards. As the eye was already lost, I made no incisions. Three days after, under poulticing, pus began to discharge through the conjunctiva oculi, with occasional shreds of necrosed cellular tissue. About a week after this, when the swelling had very much abated and the eye had retreated considerably, the cornea became badly infiltrated, and soon sloughed away, leaving a shrunken globe.

A stout laborer was struck by the fist on the outer part of the orbit. Decided exophthalmus soon followed. The eye was limited in its movements, and very painful when pushed backwards. A few days after, fluctuation was felt through the upper and lower eyelids. I made free incisions, as usual, with discharge of matter. Excepting some symblepharon and slight impairment of sight, this patient got well.

Evidently here the suppuration was not deep behind the eye, and the vision was damaged, but not destroyed. In the case of spontaneous cellulitis, occurring in the puerperal period, the cornea was insensible from the beginning, and was finally destroyed by sloughing in consequence of its anæsthetic state. When the protrusion was greatest, the enormous chemosis covered and protected the cornea. As it subsided, the cornea was more exposed, and succumbed at a period when it would not, if the normal sensibility had been preserved.

In the history of surgery, many fatal cases of penetration to the brain, through the orbit, are recorded. I have referred to one or two, in my anatomical synopsis. Remarkable histories of large foreign bodies, lodged in the socket, have been given. Haynes Walton reports a case in which an iron hat-peg, three and three-tenth inches long, entered and remained in the orbit for many weeks. It was successfully extracted, the vision and movements of the eye remaining unimpaired. I myself saw Nélaton remove the ivory handle of an umbrella from the orbit of a man, after it had sojourned there three years. It was nearly two inches in length, and half an inch in thickness. I had seen the same patient before at Desmarres's Clinique. Military surgery contains accounts of many wonderful injuries of the orbit and eye, by gunshot projectiles and other weapons. A Union general, now living in Washington City, had both optic nerves severed by a ball that traversed from temple to temple, behind the eyes. I saw him some months after the casualty, and both optic nerves were white. Rising from the perusal of these histories, one feels that nothing possible, is *impossible*! Injuries and diseases of the antrum, frontal sinuses, and ethmoid cells, as far as they lead to troubles of the eye, can only be mentioned here. Bearing in mind their anatomical relations, the intelligent diagnosis of these diseases is not difficult. I have several times seen fistulous openings into the frontal sinuses mistaken for fistula lachrymalis. And what surgeon has not witnessed the professional alarm at emphysema, in wounds of the ethmoid and frontal sinus? Intelligence is always cool and collected. Ignorance is rash and emotional.

TUMORS OF THE ORBIT.—Almost every form of morbid growth found in the body, is represented in this cavity. In the various neoplasms that originate here, or encroach upon this space from without, there is one most characteristic symptom—exophthalmus. According to the seat and size of the tumor, will be the direction and degree of the protrusion of the eye. A growth in the funnel-space behind the eye, especially if quite at the apex, may not cause noticeable prominence for a long time. Impaired vision from pressure on the optic trunk, and disturbed circulation of blood in the retina, may be the first evidences of such an affection. At length the exophthalmus, usually in the direct axis of the orbit, attracts attention. But for a long time nothing can be felt by the finger, the eye filling so fully the space in front. Then, when the globe is almost out of the socket, the finger, pressed behind, detects the cause. I have notes of a number of such cases, of which the following three are samples:—

A stout lady, of ruddy complexion and perfect health, consulted me ten years ago, for blindness of one eye. There was white atrophy of the optic papilla and complete abolition of sight. She complained slightly of a feeling of pressure behind the eye. This condition continued, and at the end of about two years I noticed beginning exophthalmus. This increased slowly, and I determined to operate. The protrusion was direct, the rotation almost perfect, and by partially luxating the eye with my finger, I could feel a very firm growth pushing the eye forwards. The eye being hope-

lessly blind, I did not hesitate to enucleate it. This preliminary operation was extremely easy. I then had free access to a very hard mass, that completely filled the socket. It was thoroughly dissected out, and was found to embrace the atrophied optic nerve. Recovery was prompt. In about two years a reproduction was detected, growing from the apex of the orbit. Its progress was very slow and not at all painful. At length a second operation, to empty the orbit, was executed. Recovery, as before, was rapid. Now she has, after several years, a renewal of the morbid growth, filling the cavity, but causing no special inconvenience. She is, and has always been, in excellent general health. The only known cause of the development of this tumor was the sting of a bee on the eyelid.

The early history of a second case, I extract from the published Transactions of the International Medical Congress, held in Philadelphia in 1876:—

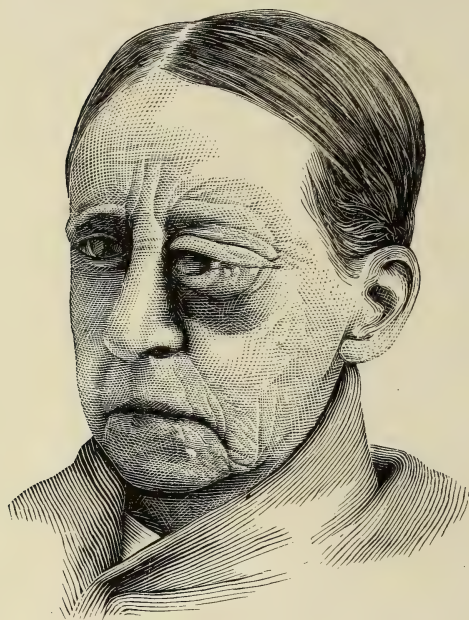
R. W., aged twenty-four, of stout figure, robust health, and sanguine temperament, was injured by the horn of a calf on Jan. 18, 1876. The point of the horn struck the lower lid, glancing inwards and backwards, and entering the orbit just above the tendo oculi, causing an ugly contused wound and a severe concussion. The wound bled profusely, but healed in the course of a week without surgical treatment. There was no bleeding from the nose; no ocular hemorrhage; nor was the patient rendered unconscious by the shock. Sight was not affected, and there was no diplopia, headache, giddiness, or other symptom of injury of the brain. There was no protrusion noticed. About five weeks after the accident, while stooping and driving a cross-cut saw, a sharp pain was felt above the right eye, running back over the ear to the temple. This sharp, peculiar pain came on at intervals, several times during the day, but was always provoked by stooping or straining, and soon passed off when the patient straightened himself up, and rested from sawing. There was no giddiness, throbbing, or bruit. Late in April, it was first noticed that the sight of the eye was misty at times, but without pain or other symptom of disease. For this failure in sight, a physician was consulted, who first detected an undue prominence of the eye. From that period, about May 1, for about three months, the exophthalmus increased slowly, but varied very perceptibly between morning and evening, being always greater in the morning. After that time it remained stationary. When I first saw this patient, in August, there was a striking exophthalmus of over one-fourth of an inch, with slight injection of the sclerotic conjunctiva, and some serous, chemotic swelling within the external commissure. Corresponding to this were seen some large, deep-seated, inosculating vessels on the sclerotic. The pupil was larger than the other, and somewhat sluggish. The movements of the globe were limited by its prominence, and by the stretching of the muscles, but there was no paralysis. There was a divergence when fixing with the other eye, and the motion upwards and inwards was less excursive, but there was no diplopia, which I attributed to the imperfect sight. Strongly marked features of swollen disk, and some neuritis; boundaries of the disk obscured, and veins very large and tortuous to their extreme branches; slight alteration of the macula lutea, blurring its distinctive features. Vision very defective in consequence of a large central scotoma, which patient expressed as well defined, but not complete. Tension of the globe, natural. No pulsation whatever of the globe, nor bruit on auscultation. When the eyeball was pressed directly backwards, it was arrested by a solid resistance.

Diagnosis: Tumor of some kind at apex of orbit, probably of aneurismal character. In the complete absence of the three most characteristic symptoms of aneurism—pulsation, bruit, and some degree of elasticity on pressure—I relied, in coming to this opinion, upon the evidently traumatic origin of the affection, upon its peculiar history, upon the absence of inflammatory symptoms, and upon the exclusion of the symptoms of either benignant or malignant tumor at the apex of the orbit. The symptoms followed so soon after the injury, and in the beginning were so characteristic, as to make this opinion more probable than any other. The sudden, sharp, severe pain running backwards over the temple, and caused by stooping and straining, coming on about four weeks after the blow, might be explained by the sudden rupture of the ophthalmic artery, directly as it entered the orbit through the optic foramen.

This patient was presented to the ophthalmological section of the congress for examination; but none of those present were willing to venture a positive diagnosis.

On April 15, 1877, the patient again called on me at my office. There was then great protrusion of the eyeball, with aggravation of all the other symptoms, and a tumor could now be felt behind the globe. Enucleation of the eyeball was resorted to, as the vision was then lost from optic atrophy. The tumor was readily removed. It was firm and fibrous in character, and the size of a small pullet's egg. It was situated between the optic nerve and the inner wall of the orbit, but was not firmly connected with either. The mistaken diagnosis in this case was perhaps excusable. It was certainly instructive. The recovery was permanent, and the patient wears an artificial eye. This indicates that the tumor was a benignant growth.

Fig. 918.



Fibro-sarcoma of orbit causing exophthalmus.

times, aching pain. Nine months subsequently, the exophthalmus having increased and the pain being constant, she consulted a physician, who discovered a swelling at the outer, inferior margin of the orbit. For the next two years all the symptoms grew worse, till she was no longer able to close the lids without great effort. There was no history of injury, nor of any hereditary predisposition. Her health had never been robust, and yet she had, in her whole life, not suffered from any serious illness. At the date above given, the exophthalmus was enormous, the displacement being inwards and upwards; the cornea was clear and the pupil active, and she counted fingers at twelve feet; the ophthalmoscope revealed partial atrophy of the disk, with marks of neuritis; the margins of the papilla were ill-defined and irregular, and the veins tortuous. An elastic growth, filling the orbit, and projecting in a nodular form at the lower, outer part, could be distinctly felt. The patient was in constant dread that the eye would "come out of her head," and had to push it back often with her hand. When ready to enucleate, I pushed the lids back beyond the eyeball, where they closed in tightly, so that no speculum was needed. The removal of the eye was extremely easy, and I then passed my finger back and pulled out the tumor. It was moulded to the general form of the cavity, but was more prominent outwards. Dr. Robert Sattler's microscopic examination revealed a fibro-sarcoma. There has been no return, and the patient wears an artificial eye comfortably.

If the tumor is seated backwardly and inwardly, the eye will be pushed forwards and outwards. The displacement is always in the opposite direction to the seat of the growth. When far forwards, the eye is displaced laterally, and but little increased in prominence. Double vision is a common cause of worryment, when the dislodgment is indirect and considerable. If not directly invaded by the morbid growth, the rotatory muscles preserve their

The third illustrative case has furnished the subject of Fig. 918:—

Mrs. B., 62 years old, applied for advice in November, 1881. She said that the disease had begun three years before, and assigned it to the sting of a wasp. Soon after, her friends noticed a slight prominence of the eye; she felt some discomfort when exposed to the wind and bright light, and, at

functions for a very long time. The limitation is first and chiefly noticed towards the side of the tumor, and is in proportion to its size. The lids stretch with the slow increase of the exophthalmus, and still cover the eye, even in the extremest cases. If the progress is rapid, the pain, impaired motion, double vision, and violent reaction from exposure, show themselves much earlier. In that event, ulceration of the cornea and loss of vision may be expected much sooner.

Of the many kinds of orbital growth, some are fatally malignant, others less so, and some harmless, except from the want of room. Some are extremely firm, others less so; some are cystic or mixed, others bony. In some instances the growth is very slow. These are apt to prove benignant. Others, of rapid progress, are more likely to be malignant. The different kinds of vascular tumor are generally traumatic, and sudden in their appearance. Exostoses are always of very slow growth, especially those of the ivory variety. When accessible to the touch, much may be learned of the tumor's consistence by that means. A case in point, of exostosis, is the following:¹—

Mary E. T., 23 years old, of rugged constitution and in good health, consulted me March 13, 1878. It was difficult to procure a clear history of her case, on account of the patient's stupidity. For three years the family had noticed a divergence of the left eye when she fixed objects closely, or was embarrassed. About one year before, an unnatural prominence of the eye had been observed. Since that time exophthalmus and divergence had slowly increased, and the sight had disappeared. No traumatic or constitutional origin of the affection could be traced or even supposed. Her health had been uniformly good. The patient had a broad face, flat nose, and stolid expression. Her condition, when examined, was found to be as follows: The left eye was pressed upwards and outwards, and protruded to such a degree that the centre of the cornea was half an inch in advance of the other; the movements were limited downwards and inwards, but free in other directions. With that eye she had only vague perception of light, the sight of the other being perfect. The prominence was so excessive that slight pressure on the upper lid caused it to close in behind the ball. At the lower and inner part of the orbit a tumor was seen, dislodging the eye—bony hard to the touch, somewhat nodulated, but round, and extending deeply into the socket; the pupil did not respond to light, when the other eye was excluded, but remained large and fixed. With the ophthalmoscope I discovered marked neuro-retinitis from stasis; the entire retina was hazy, and the vessels were tortuous and obscured at many points with exudations; the disk was much engorged, and its margins were difficult to identify. It was evident that the eye was visually useless, and, the tumor being large, deeply seated, and firmly attached to the os planum of the ethmoid, I thought it safest and best to enucleate the eye and then remove the growth; this was done with the patient under ether. After enucleation, I found by the finger that the tumor was firmly united to the inner wall of the orbit, and extended nearly to the apex. Cutting through the capsule of Tenon and the periosteum, I denuded the mass as extensively as possible; then, with the bone-nippers, an effort was made to cut off a portion of it, but it was so hard that with my utmost strength I could only bring away very little. I then opened a strong pair of bone-forceps very widely, forced them over it so as to secure a firm hold, and by a few wriggling movements detached it *en masse* from its connections, and drew it out, thus completing the operation in a few minutes, and without any shock from chiselling or slipping of the forceps. But little bleeding occurred, and the patient soon rallied from the ether. Two days afterwards she returned to her home in the country; the following night, however, my assistant was called to her to arrest a severe hemorrhage from the nostril of that side. A section of the tumor measured 16 mm. in its longest diameter; in its transverse diameter it measured about 10 mm.; the rough bony pedicle measured 8 mm. in one direction, and 5 mm. in the other, showing that it was continuous with the os planum by a constricted neck. The entire growth came clean away, bringing no true bone with it. It was as hard as ivory throughout, admitting of a nice

¹ Transactions of the Am. Med. Association, vol. xxx.

polish, and, when being sawed, emitted the peculiar smell of ivory. Its general form (supplying the portion that was chipped off by the nippers) was round, similar to a walnut, but nodulated and traversed by a deep fissure, which passed around it, between the pedicle and the convex portion that pressed against the eye. Its weight was 3 drachms, and with the portion that was chipped away would have been, perhaps, half a drachm more. No vessels were to be seen on its surface or in its structure. The patient returned about a year after the operation to procure an artificial eye, and there was no trace whatever of any reproduction of the tumor.

These operations are always difficult and tedious, and often only partially successful. If possible, the eye should be preserved in all operations in the orbit. But sometimes enucleation is a necessity; and it always greatly facilitates the removal of an orbital tumor. If sight is gone, the sacrifice does not seem very great. Any mutilation, when necessary to save life, is justifiable. Very great care is needed to save the eye from injury, with its muscles and optic nerve. Sometimes one or more of the muscles must be cut, and the ball luxated by the finger, to secure access to the tumor. When the operation is completed, the divided muscles may be stitched, and deformity thus prevented.

Cysts originating in the ethmoid bone, and sometimes in the orbit, can only be treated surgically. They are filled with colored, ropy fluid, mixed with firm flakes. Free incision, syringing out the contents, and the use of irritating injections will generally succeed in effecting a cure.

The following case is typical of this class of tumors:—

A stout, healthy man from the country consulted me for a very high degree of exophthalmus of the right eye. A small scar just above the orbit was the result of a severe blow received when a boy. Besides this no other injury could be recalled. The protrusion was so great that the eyelids could only be closed by an effort. He dated the commencement of this symptom back only six months. The luxation was forwards, downwards, and inwards. A fluctuating tumor was felt between the ball and the upper and outer part of the orbit. I elevated the lid, and thrust a trocar through the cul de sac of the conjunctiva in the direction of the tumor. About an ounce and a half of ropy, slightly reddish fluid escaped. The ball sank back almost to its natural position at once. On his return in two weeks, a re-accumulation had taken place, but much less in quantity. A similar puncture was made with the same result as before. A few weeks later I saw him again. The exophthalmus was as marked as on the first visit. I then made a free incision, over an inch long, through the skin, parallel with the margin of the orbit, and opened the cyst extensively. After the escape of the contents, the sac was syringed with water, when three or four masses of coagula, each nearly as large as the little finger, were washed out. By examination with the finger the cyst was found to be very large, extending to the apex of the socket. As much as possible of the wall of the cyst was removed with scissors. For several weeks the cavity was daily washed out with water, and the incision kept open by a tent. Finally, the tent was left out, the wound closed, and the patient was well for about a year. The remaining exophthalmus was slight; the vision, at first much impaired, improved till he could read No. 8 of Jaeger's tests. He came back a year after with a decided return, which had appeared within two weeks. There was no pain, redness, or soreness on pressure. I incised the cyst freely as before, and about an ounce of pus, mixed with the same glairy, ropy fluid escaped. A probe detected denuded, but smooth, bone at the apex of the cavity. The wound was kept open as before, the cavity washed out daily with water, and injected with pure tincture of iodine. This was done for a week. The tent was continued for ten days afterwards, and at that time the bare bone was covered, and the cavity much reduced in size. Still, a little glairy fluid escaped each day with the pus. I then injected for three times, every second day, a 60-grain solution of nitrate of silver. In a week after that treatment I found the cavity very much smaller, and bleeding readily when touched with the probe. I then injected the iodine for three successive days. The tent was used for several weeks till the cavity was permanently obliterated, so that nothing was seen but an indrawn cicatrix.

Nothing but persevering and heroic treatment can destroy such cysts. I have repeatedly dealt with cysts of the ethmoid bone in a similar way. They encroach upon the orbit, interfere with the tear-sac, push the eye to one side, and demand treatment. Where the shell of bone over the cyst is thin, a peculiar feeling and crepitus are detected, when it is pressed with the finger. In one instance this was very striking.

Tumors of the optic nerve usually destroy vision, and the protrusion is in the direct line. In rare cases, the tumor and nerve have been removed, leaving the eye, but, as a rule, the useless eye is sacrificed, for the readier removal of the tumor.

Vascular tumors of the orbit, always attended by pulsating exophthalmus, present very different appearances, on post-mortem examination. In some, where this symptom was intensely marked, and a shrill bruit was audible over the eye, but little alteration was found after death, and this mostly in the cavity of the cranium. As a rule, these symptoms are found to be due to a traumatic rupture of the carotid artery in the cavernous sinus. I have seen but two cases of genuine aneurism of the ophthalmic artery. One was produced by a small shot that penetrated the orbit and wounded the artery. It was cured by compression. I published, many years ago, a case of very great protrusion of the eye, with pulsation, and a loud bruit, attended by optic neuritis. The papilla was greatly swollen, the vessels were very tortuous, and there were numerous hemorrhages in the retina. A cart-wheel had passed over the man's head a short time before the disease developed. The late Prof. H. E. Foote, at my request, ligated the carotid artery with temporary benefit. Six weeks after, the murmur and pulsation having returned, he tied the other artery, with the result of effecting a complete cure. In nearly all cases of tumor behind the eye, the exophthalmus and impaired sight are united with great swelling of the optic disk from venous stasis. In a man seen recently, with great prominence of the eye and but little sight, the swollen papilla was remarkable. It stood out into the vitreous with its round form perfectly defined, and the vessels passing up over it as if springing up on an artificial mound. By deep pressure at the upper and inner part, the edge of the retro-bulbar growth could be felt. Operative interference will soon be imperative. A malignant tumor of the orbit, in a little girl, became so large and produced such pressure, that in the midst of a fearful paroxysm of pain the whole superior maxillary suddenly separated from its fellow with an audible noise. The pain ceased instantly, and the teeth of that side projected half an inch beyond the line of the others. The detachment was from the median raphe. The child died a few weeks afterwards from invasion of the brain. The enormous size that these fatal growths attain, is almost beyond belief. In such extremities, death is a most welcome visitor.

INJURIES OF THE EYEBALL.

That the eye is a *delicate organ* is best known to the surgeon acquainted with its sensitive structures and exquisite functions. In spite of the bony safety-box in which it is so nicely pivoted, the fatty cushion behind, and the watchful shutters in front, the eye is often surprised and seriously injured. Always open during the wakeful hours, it is constantly exposed to the vapors and fine dust of the atmosphere. Cinders and other particles driven by the wind, often strike the eye and fix themselves upon it, causing great suffering. It would be impossible to enumerate all the parts of seeds and grains, scales of insects, and other trifles, for which there is no room in the eyes!

FOREIGN BODIES IN THE EYE.—Foreign particles that remain any time in the eye, nearly always fix themselves in one of two positions. They adhere to the eyeball in front, generally to the cornea, or sweep under and fasten themselves on the inside of the upper lid. Rarely, they gravitate between the lower lid and the ball. Instinctive resistance to any sudden feeling of something in the eye, prompts to spasmodic closure of the lids and rude rubbing with fingers or knuckles. This often fixes and imbeds the cinder, while promptly seizing the lid and holding the eye open, would favor its escape with the gush of tears. The circumstances under which the trouble occurs, will often help to decide *what it might be*; but only a thorough examination can determine *what it is*. When consulted for a supposed foreign body in the eye, or when that is a possibility, though not suspected by the patient, a critical inspection of the cornea and the eyeball should be made. To do this, good light and good sight are indispensable. Separating and holding the lids gently apart, and directing the patient to turn the eye as desired, the surgeon makes a hasty search of the entire surface of the cornea. If the foreign body is very minute, of a dark color, and lodged near the centre of the cornea, it is better seen obliquely, as you thus get a background of iris rather than of black pupil. Should it be of light color, it will require very close attention to see it. *Oblique illumination*, using a large collecting lens of about three inches' focus, will materially aid the search. Common day light, and still better, a good lamp light, may be thus focussed upon the cornea, and promenade over its surface. While the seat of the foreign body may be made clear by focal illumination, another similar lens may be used to magnify it and make its detection certain. By these aids, it cannot escape notice, however small. If nothing is found on the cornea or ball by a hasty but adequate inspection, the surgeon should evert the lids and scrutinize their conjunctival surfaces. The lower lid is easily everted by drawing it down towards the cheek, directing the patient to look up, but the foreign body is far more likely to be found under the upper lid. To evert it is not so easy, and requires professional tact. Seize the lashes near the middle of the lid with the thumb and index finger of the left hand, and direct the patient to look steadily and far down. Then drawing the lid slightly away from the eye, and downwards, you press a small probe, the end of a pencil, or even the tip of the finger, above the tarsus, sliding the lid down while the free edge is raised by the left hand, and the eversion is accomplished. Nothing but practice, with light and intelligent fingers, will make this important manoeuvre easy. There is no one thing by which a patient who has been once handled by expert fingers, will detect awkwardness and inexperience as quickly as by the way the upper lid is everted. Finding the foreign body, probably on the tarsal surface, near the free edge of the lid, you can readily remove it, and the agony is over. Or failing still to find it, you next explore, as best you can, the upper, concealed folds of conjunctiva. Keeping the lid everted, and the eye turned far downwards, you place the probe on the skin far back, press it downwards, and then hoist it forwards, thus prying out the folds. Strings of matter, granulations, or warty excrescences, may be discovered surrounding a beard of wheat or barley, a grain of wheat, a piece of straw or splinter of wood, a husk of some seed, or other intruder. Thus it is found and removed. That done, little or no other treatment is required. The patient may have suffered for months, and been blindly tortured with the severest remedies. If only one eye has been affected with stubborn conjunctivitis, without chronic disease of the tear sac, this thorough search for a foreign body lodged in the upper folds should not be neglected. It will often lead to brilliant discoveries, and secure the lasting gratitude of the patient. I have removed scales of seeds, wings of insects, and other foreign bodies that had been fast-

ened on the cornea, in plain view, for months, and the irritation aggravated by severe local astringents. I once found a dry stramonium seed in the upper cul-de-sac of the conjunctiva; it had been in the eye some thirty-six hours, and the pupil was widely dilated. Small particles of steel, stone, powder, and other hard substances, driven not by the wind but by mechanical forces, may not merely lodge on the eye or under the lids, but be more or less deeply imbedded. There is, then, generally, more reaction, pain, and traumatic inflammation, both before and after removal. If the foreign body be on, or imbedded in, the cornea, photophobia, spasm of the lids, and weeping, may seriously embarrass the examination and necessary treatment.

The *removal of foreign bodies from the cornea* is not always easy, especially when they are metallic, and have remained several days. Undergoing chemical changes, the oxidized substance incorporates itself with the corneal tissues, producing a dirty-rust ring. This will remain after the little mass of metal has been removed. By some persistence this ring can be detached. It is essentially foreign. A sharp spud, or a sort of gouge (Fig. 919), is better for removing particles from the cornea than a needle, and less dangerous in inexperienced hands. An operating chair or lounge may be used to seat the patient, or to lay him comfortably down. Standing behind or beside the patient, as may be most convenient, the lids are separated by the left hand, and the spud held in the right. In holding the eyelids securely open, with the thumb and index finger, care must be taken not to evert them. The patient is urged to hold the eye still in a given direction. The first touch of the cornea will make him wince from apprehension, but he will soon learn to control the eye. A good light and a favorable position for seeing the foreign body are indispensable. Then supporting the ball, with the lids well apart, the surgeon perseveres till he has completely removed the foreign body, with its stain, if such exist, doing as little damage to the cornea as possible. If the particle be more deeply imbedded, the spud may not succeed, and a broad needle (Fig. 920) will serve best. If the patient cannot control his eye, a speculum (Fig. 921), fixation forceps (Fig. 922), and even ether, may be used. In rare instances a scale of metal, piece of cap, or glass,

Fig. 919.



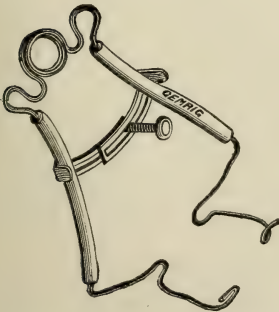
Spud for removing foreign bodies from the cornea.

Fig. 920.



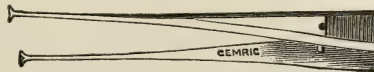
Broad needle for removing foreign bodies from the cornea.

Fig. 921.



Liebreich's spring-stop speculum for separating the eyelids.

Fig. 922.



Fixation forceps.

may be driven so deep as to be ready to fall into the aqueous chamber. The least touch of the needle might push in the foreign body, when it would

naturally fall to the bottom of the chamber and soon create violent reaction. The difficulties and dangers of removal would be then greatly increased. In every case where such an accident is imminent, thorough anæsthesia is necessary. The spring speculum and fixation forceps must be applied so as to secure the greatest accuracy in the use of instruments. A narrow, very sharp, spear knife, bent on the flat, must be passed through the cornea a little to one side of the offending body, and pushed carefully through the chamber till well behind it. Then by depressing the handle, the blade, with its flat surface, is brought firmly against the cornea, and the possible entrance of the foreign body into the chamber is blocked. While one hand thus carefully holds the foreign body, the other picks or prizes it out with a broad needle. The fixation forceps, at this stage at least, must be held by an assistant. No operation on the eye demands greater coolness and skill than the manœuvre described. Should the aqueous humor escape before the object is attained, the surgeon must desist and wait for its reaccumulation.

The length of time that a foreign body may remain buried in the cornea, undiscovered, is illustrated by a case in which a piece of wheat-beard was removed after two and a half years:—

A farmer, in September, 1866, while feeding a threshing machine, felt something strike the left eye. Severe inflammation followed, and he was kept in a dark room for two months. The eye then grew gradually more comfortable, so that he could work, but remained delicate, till in March, 1869, when severe suffering again set in. I saw him on April 29. There was vivid ciliary injection, and intense intolerance to light. A dark, grayish speck was seen in the centre of the cornea. By oblique illumination, a distinct projection from the corneal surface was detected. This was readily removed by a spud, and at the same instant the aqueous humor escaped. On examination, the substance removed proved to be a short piece of wheat-beard which had punctured the cornea, and which after that long period had worked to the free surface.

ACCIDENTAL WOUNDS OF THE EYEBALL.—These may be, (1) Incised, when inflicted by the blade of a knife, scissors, piece of glass, or any other sharp substance; (2) Punctured, as when caused by a pin, needle, thorn, or sharp, round instrument, such as the tine of a fork; (3) Mixed wounds, of a contused and lacerated character; and (4) Ruptures of the strong supporting tunic, generally of the sclera, by blunt force, such as the blow inflicted by a windlass, the horn of a cow, the fist, a ball, or a small stone.

Incised wounds, if clean, sharp, and not deep enough to open the eyeball, are not serious, and soon heal by simple rest with the eyes closed. Even when passing through the cornea or sclera, and of considerable length, if no prolapsus of the iris or ciliary body occurs, and if no deep-seated organ, such as the lens, is injured, they soon recover with the same treatment. If, however, the anterior chamber is opened, even by a small wound, the sudden loss of aqueous is very apt to wash the iris into the open cut, producing prolapsus. This is easily recognized by the little, round, dark prominence at the seat of the cut, looking something like the head of a house-fly. With that, the pupil will be more or less eccentric and altered in shape. It will be pear-shaped, with the small end at or towards the wound in the cornea or the sclero-corneal junction.

If the vitreous cavity is opened, prolapsus of more or less of that fluid will be likely to show itself. Even here, if the cutting body has not penetrated very deeply, and if no great loss of vitreous has taken place, with intra-ocular hemorrhage, the wound may heal with little injury to sight.

Punctured Wounds.—Wounds by a pin, needle, thorn, or sting of a bee, if deep, are extremely dangerous to sight, and are liable to be followed by disastrous inflammation, even of the uninjured eye.

I once treated a woman whose eye was put out by a pin. She was beating carpet, and the pin struck the eye with such force as to penetrate deeply through the cornea, iris, and lens. She suffered for many months, but recovered with a blind eye, the good eye never having seriously sympathized with it.

On December 31, 1881, a man was struck in the face by a bramble bush. He suffered repeated attacks of inflammation, the sight growing more and more cloudy, till July, 1882, when I saw him. There was a scar near the upper edge of the cornea, and a slight synechia anterior. I saw a piece of brier in the iris, and removed it by iridectomy with the portion of iris in which it rested. The other eye was hopelessly blind from previous disease, but the eye which was operated on recovered.

Thorns of black locust, honey locust, etc., often destroy the eye, especially when a piece breaks off and remains.

Wounds of a *contused* and *lacerated* character are nearly always disastrous to sight, and often lead to grave complications, involving the sight of the remaining eye, and even danger to life. Of course, the risks are greatly enhanced by the penetration and lodgment of the wounding body, or of something else that may be carried in with it. Intra-ocular hemorrhage and inflammatory disorganization from panophthalmitis, with its violent and protracted sufferings, are almost sure to follow, in any event. In all such fatal accidents to sight, if the eye would eventually heal and remain inoffensive, it would be a happy issue; but prolonged suffering and sympathetic danger to the fellow-eye are always to be apprehended.

Ruptures of the eyeball from blunt force take place in the sclera, a short distance back of and parallel to the base of the cornea. Simple rupture of the cornea is extremely rare. In ruptures of the sclera, the yielding conjunctiva generally escapes, while the lens is often driven through the rent and lodged under the mucous membrane. In that case, a large, round elevation, formed by the lens, whose color, perhaps, may partly be seen through the distended and semi-transparent conjunctiva, will indicate what has happened. I have repeatedly incised the conjunctiva and removed the lens after this accident, with preservation of even useful vision. Patients recover with very little suffering in these cases, and the rupture is not often the cause of sympathetic loss of the sound eye.

PENETRATING WOUNDS OF THE EYE.—A question of great importance, in all cases of eye-wound, is whether or not the offending body has entered the eyeball. To determine this, is by no means easy in very many cases. If the wound is large and deep, the immediate, partial or complete collapse of the globe, and the escape of a portion of its peculiar contents, reveal at once to the most ignorant, or even careless, the nature of the injury. But if the injuring body is small and propelled with great force, it may penetrate deeply into the eye with a scarcely perceptible wound, and almost without pain. The patient himself feels sure that it could not have gone into his eye, for he hardly felt it, and he often misleads his physician. It is well known to surgeons of experience that a small particle flying with great force, and lodging deeply in the eye, hurts much less than one moving slowly and lodging on the eye or under the lid. Besides, the pain is much greater for hours, and even days and weeks, afterwards, in the latter case than in the former. It frequently happens that a foreign body of minute size penetrates the eye, producing, sooner or later, cataract, or other serious trouble, and that the patient cannot remember when, where, or how the accident occurred, so little did it attract his attention at the fatal moment. This should warn us always to make a most minute and critical examination of the eye when the circumstances prove such an occurrence possible. For instance, a slight sting is felt in the

eye of a bystander when a percussion-cap is exploded. He rubs the eye for a moment, wipes away a tear, and feels it no more. On close inspection, a particle of the cylinder is found to have passed through the cornea and lodged in the anterior chamber, the iris, or the lens—or even to have cleared all of these and gone deep into the vitreous—causing, perhaps, very little immediate impairment of vision. The first step in the diagnosis is to find the wound; the second, to determine whether or not it extends through all the coats of the eye; and the third, to ascertain if the injuring body has rebounded, has lodged in the tunics themselves, or has cleared them and entered the globe to remain. In seeking the wound, each part of the eye must be inspected in systematic order, beginning with the one most commonly injured, the cornea. In this examination we may be often guided, with some certainty, to the seat of injury, by the circumstances under which it occurred, and by the existence of a scratch or cut of one or other eyelid. But as the eye is nearly always open at such times, if the body is small it strikes the cornea directly, without grazing or passing through the lids. In these cases the diagnosis is often extremely difficult. The cornea, covered by its smooth, polished epithelium, acts as a reflector, forming images of objects in front of it. If the epithelium at any point be abraded or rough, a corresponding blur and defect will be seen in the sharp image of the window towards which it looks. The eye should be examined at an angle, and made to move slowly so that the little image may travel over all parts of its surface in succession. Another excellent means of detecting a very small scratch or wound in the cornea is by oblique illumination. Darken the room and light your gas or lamp, seat your patient facing it, and concentrate the light upon the cornea by a strong convex lens of two or three inches' focus. If an abrasion or wound, be it ever so minute, exist, you will thus see it. Of course, if the cut be large, with hernia of the iris, it is seen at once without these aids.

Discovered the seat of the wound, has it penetrated? If the iris is drawn into it by the escape of aqueous humor, forming a hernia, ever so small, *yes*. If the chamber has its relations altered—that is, if the iris is near or in contact with the cornea, whether prolapsed or not—*yes*. If there is blood in the chamber, much or little, without the possibility of a severe concussion of the eye, with or without unnatural softness of the ball to the touch, *yes*. If a small hole is seen in the iris, corresponding in size to the corneal wound, and in the probable direction of the penetrating body, with or without blood in the chamber, or alteration of the depth of the chamber, *yes*. If the foreign body can be certainly seen in the iris, lens, or chamber, *yes*. If, with the wound of the cornea, with or without changes in the chamber or the tension of the globe, the lens is becoming certainly milky, showing beginning cataract, with perhaps a visible wound in its capsule, *yes*. All of these symptoms failing, in a case of manifest wound of the cornea, you dilate the pupil and use the ophthalmoscope. If the fundus of the eye is darkened by blood, the circumstances precluding rupture of intra-ocular vessels, there is almost certainly penetration. If the foreign body can be positively seen within the organ—in the chamber, iris, lens, vitreous, or retina—the diagnosis is sure. Of course, impairment of sight and the appearance of a cloud in the field of vision, caused by extravasated blood or the foreign body, or both, come in as corroborative evidence of penetration. The sight may be destroyed at once or very soon; or it may be little affected, according to the size, direction, and final resting place of the offending body. The value of softness of the globe, as an evidence of penetration, is very great, when it certainly is present. But the tension is often not altered. If the foreign body is small,

it may pass deeply into the eye without any escape of humor, either aqueous or vitreous, and hence may leave the tension normal.

When the patient is not seen for some minutes, hours, or even days after the injury, the wound may be firmly closed, and the lost humors reproduced, so that undue softness is no longer present. The reproduction of lost humors is very rapid, as is known to all operators on the eye. In fact, if the patient is not seen for several days, the eye may be too hard, from internal inflammation and secretion; this increased tension then becoming the indirect evidence of penetration.

The ophthalmoscopic evidence of penetration, when positive, that is, when the body itself is seen, or suffused blood, or a cloudy sleeve of opacity along its track in the vitreous, is quite sufficient. Still, the result of such an examination may be altogether negative, and yet the offender be in the eye. Should it rest far forward in the vitreous—behind the iris or ciliary circle—it is detected with great difficulty, if at all. In that case, there being none of the symptoms already emphasized, we should make a reserved diagnosis and wait for further developments; should the extraneous body be in the eye, it is almost certain to give rise to trouble sooner or later. Moreover, the supposed visible intruder may prove to be a globule of blood, or air, or both; but that does not invalidate its importance as an evidence of penetration. On the question of the actual presence of the foreign body in the eye, it may leave doubt which can only be cleared up by time. So the cloud seen by the patient, after an injury, may or may not be caused by the presence of a foreign body in the globe, but is strong presumptive proof of penetration.

But the eye may be struck behind the cornea, in the sclerotic region. And as this part of the globe is covered by conjunctiva and capsule of Tenon—both being thin, elastic, and movable over its surface—the wound may easily escape notice when small. Its torn edges, and especially the ecchymosis, always, perhaps, present for a short time after the injury, will attract attention to the injured spot. The thing, then, has struck there, but has it entered? If the spot is over the sclero-corneal junction, or very little back of it, we may still look in the anterior chamber for signs of the passage of the wounding body. The iris may be wounded near its ciliary margin, or a small knuckle of its periphery may protrude through the wound. Blood in the aqueous chamber has here also the same positive significance as in wounds through the cornea. Should neither prolapsus iridis, hemorrhage, nor any appreciable rent in the iris be discovered, it is still wise to make a scrutinizing search with the ophthalmoscope, in this, as in all cases of suspicious injuries of the eyeball. Physicians in general pass too lightly over such accidents, assuring the patient at once, perhaps, that nothing is in the eye.

I would insist upon the importance of small wounds of the iris, sometimes forming a sharp hole in this curtain, admitting light, and giving a red reflex from the bottom of the eye with the ophthalmoscope. They prove not only penetration, but the almost certain presence of the foreign body in the back of the eye. A very small hole or cut in the iris, can only be made by the passage of a very small body, and one which must clear the cornea before striking the iris. Rebounding in that case is impossible. Such an injury could only be caused by a small body, or by a pin or needle, a splinter, or some long, slender projectile. In the latter case, the missile might rebound. If, however, it has also cleared the iris, and is hence invisible, it may be found in the suspensory ligament or margin of the lens, or in the vitreous behind it. The body being small and the edge of the lens barely grazed, there is not likely to be traumatic cataract—an infallible evidence of penetration when it is detected. The ophthalmoscope may or may not detect the foreign sub-

stance in the fundus. The same observations which were made above about ophthalmoscopic evidences of penetration, and their significance, apply here.

If the wound in the conjunctiva and sclerotic is large, and made either by a large body entering directly, or glancing, there will probably be loss of vitreous, recognized by its characteristic ropiness, and flabbiness, or collapse, of the globe. In this event, the foreign body may be lodged in the globe or not. In such destructive injuries there is almost certainly free hemorrhage within the eye, preventing any immediate inspection of the fundus. But a wound of the sclerotic conjunctiva does not necessarily indicate penetration. The injuring body may have glanced backwards, between the conjunctiva and sclerotic, piercing the latter perhaps in the region of the equator, or sparing the globe and plunging deep into the socket. Sometimes a shot, or scale of metal, when driven with great force, passes entirely through the globe and lodges in the apex of the orbit. In rare cases a rough scale may be found grasped by the sclerotic, after having traversed the vitreous.

Some years ago a machinist called on me with an injured eye. There was a large ragged wound in the sclerotic, the ball being flabby and filled with blood. I was sure that a rough scale of metal had entered deeply and had remained in the ball. Immediate enucleation was urged, but the patient would not consent. The eye was hopelessly lost, and great suffering was certain to ensue, with much danger to the other eye, and even to life. But I could not move him from his conviction that there was no foreign body in the eye, and that the sight could be restored. Of course I refused to prescribe, or to take any responsibility in the case, and the patient left me. Two weeks afterwards he returned, with fearful swelling of the eye and face, excruciating pain, and commencing rigidity of the muscles of the jaw. In this extreme condition, hopeless as it was, he begged for enucleation. The operation was very difficult, and when at last the optic nerve was embraced by the scissors, they would not close. After much trouble, however, I succeeded in removing the eye. A large metallic scale was found embraced by the wounded sclerotic, one end projecting backwards by the side of the optic nerve. The tetanus continued, as I expected, and after the most fearful sufferings I ever witnessed, the poor victim died, two weeks after the operation.

Another somewhat similar case was operated on by my associate, Dr. S. C. Ayres, on the 10th of April, 1876. Immediately after enucleation, the ball was opened and examined. To our surprise, no foreign body was found, but a cicatrix, three lines in length, was detected in the sclerotic just below the optic nerve, through which it had passed out of the eye into the orbit. The socket was at once examined by the operator's finger, and the end of the foreign body distinctly felt, wedged back into the apex. With a good deal of trouble, it was seized and removed by the forceps. It was five-eighths of an inch in length, and three-eighths in breadth, and somewhat like a piece of knife-blade.

I have, several times, enucleated eyes where the sight had been destroyed by birdshot, and where none were found in the globe, but distinct cicatrices of entrance and exit. Such shot or bullets may sojourn in the socket perfectly harmless. In one instance, however, I saw an aneurism of the ophthalmic artery developed some months after such an injury. Occasionally a penetrating body, or a shot, spares the eyeball, but plunges behind it and wounds the optic nerve, causing instant loss of sight.

Sudden loss of sight following a penetrating wound of the orbit—the eyeball itself having escaped injury—may thus be accounted for.

I once saw a young man who had fallen from a load of hay on the sharp, slender tine of a steel fork. He jerked it out, with some difficulty, but never saw light afterwards. When I examined him many years afterwards, I found the cicatrix in the upper lid, but no trace of injury in the globe. On ophthalmoscopic examination, I found nothing but extreme white atrophy of the optic nerve. It is almost certain that the nerve had been wounded, perhaps severed, by the fork.

A still more interesting case occurred in my practice, some years ago. An old gentleman received an accidental discharge of birdshot in his face, with immediate total extinction of sight in both eyes. Two days afterwards I saw him, and found his condition, briefly, as follows: The right eye was collapsed and riddled by shot, and there were numerous marks of others that had entered the face and lids of the same side. The left side of the face showed only one mark of a shot in the lower lid, opposite the edge of the bony orbit. The pupil was largely dilated and fixed, with bare perception of light. Otherwise the eye was intact, and the ophthalmoscope revealed absolutely nothing wrong. The disk appeared natural in all respects, and moderate pressure with the finger on the globe produced the usual visible pulsations of the arteries on its surface, showing that the main retinal artery, as it enters the trunk of the nerve a little back of the globe, and follows in its axis to the interior of the eye, had not been injured. I diagnosed injury of the optic nerve some distance behind the globe, beyond the point at which it receives the artery. The patient suffered great pain in the right eye, for which I was induced at last to enucleate it. One shot was found in the bottom of the vitreous, but the others had passed entirely through, into the orbit. He was altogether free from pain afterwards. The vision of the left eye gradually returned, so that he could see to walk about, recognize persons, and read large print. The optic nerve showed moderate white atrophy.

An enumeration of all the kinds of foreign body that have been known to penetrate the eye would be an impossible task. The most common are pieces of metal, percussion-caps, fragments of stone or wood, and shot. Sometimes we are surprised to find the foreign body very different from what we had expected from the history of the accident and the nature of the wound or cicatrix.

For instance, a little boy, five years old, was amusing himself by exploding caps, laying them on the pavement and striking them with a stone. A fragment struck the inner segment of the cornea, and made a wound of about one line in length. For some days he did not suffer much pain, and his physician thought the injury was not serious. At length, the inflammation and pain increasing, he was brought to me. The iris was discolored, and pressed forward almost in contact with the cornea; the lens was opaque; the foreign body had evidently passed through the cornea, the iris, and into or through the lens. It was not possible to detect it. I enucleated the eye, expecting, of course, to find a piece of cap in it. After severing the recti muscles I passed my finger behind the globe to luxate it. The pressure caused the corneal wound to open, and the soft opaque lens escaped from the eye. I caught it, fortunately, and dropped it into the basin. On finishing the operation, and opening the eye very carefully, I found no piece of cap; the lens in the basin was then examined, and a small piece, not of the cap, but of stone, was found in it.

Another time, an eye had been extinguished by the sudden discharge of a gun-cartridge. The evidences of penetration, and of the presence of a foreign body deep in the eye, were clear. I discovered in the enucleated eye a piece of *mother-of-pearl*! On careful inquiry, the patient confessed that he had been foolish enough to strike the cartridge with his pearl-handled knife; the cartridge exploded, and all that he ever saw of the knife was the piece of pearl found in the vitreous.

Another man, while handling some pieces of wood, felt something, he did not know what, strike his left eye. It produced a triangular, incised wound of the cornea, injured the lens, and caused cataract. Sight was lost at once, and for seven weeks he suffered constant pain. At that time the cornea was flattened, opaque in the centre, and apparently drawn down by the cicatrization; the ball was tender to the touch, over the ciliary region; the sclerotic and ciliary zone were intensely injected. On removal, the vitreous was found liquid; the retina in position, but in thickened, opaque folds. Corresponding to the corneal wound was a cicatricial, tense ridge, or band, running across the ciliary processes, and having a firm, fibrous feeling and resistance. Within this cicatrix was included an *eyelash*, lying in the direction of the cicatrix, with the bulbous end farthest from the cornea. No other foreign substance was found; the wounding body had carried the cilia in, and had left it, after rebounding.

The presence of a foreign substance remaining in the ball, after penetration, increases the gravity of the case more or less, according to its nature, size, greater or less roughness, and especially its position. A small, smooth body may become encysted in the vitreous, and remain harmless. Indeed, this may occur, but rarely, when it is in the iris, retina, or choroid. In such instances its presence is nearly always resented, and it keeps up endless trouble and never-ceasing danger to the other eye. When fixed in or near the ciliary region—the most usual place—there is certainty of trouble sooner or later, and great danger of sympathetic ophthalmia. It is in the lens, perhaps, that extraneous bodies are longest tolerated, after producing cataract. But eventually they may escape from the lens and produce violent and destructive reaction:—

A man while opening a keg of paint, in April, 1875, with a hammer and chisel, felt something strike his brow, bringing a drop of blood; at the same moment a stinging sensation was noticed in the eye. There was no pain following the accident, and he insisted that the sight remained perfectly good until three weeks before I saw him, which was over a year. At that time, May 22, 1876, he could only count fingers at $3\frac{1}{2}$ feet. There was cataract, but without complete opacity. Deep in the lens was seen a shiny, small piece of metal. In the anterior capsule was a visible wound, with a tuft of lens-substance protruding through it into the aqueous, and undergoing absorption. In the cornea, a small scar was found where the metal had entered. The patient called to consult me about the failing sight. I advised him to wait a few weeks, as he was suffering no pain. There were no urgent symptoms. I believed that the absorption through the rent in the capsule would go on, and that eventually the foreign body would come forward and be more easily and certainly removed with the lens. Before long he returned, having suffered intense pain for the previous ten days. The foreign body had come forward, out of the lens, and had fallen into the anterior chamber. It was very small, but distinctly visible, lying in the lower rim of the anterior chamber. The patient having been etherized, I made a careful incision at the sclero-corneal junction close in front of the offending substance. The corresponding part of the iris was then drawn out and snipped off, bringing with it the piece of metal. It was not larger than half a pin's head.

I had another case under observation, where a piece of metal, of much larger size and of crescentic shape, had penetrated the lens some years before, and still remained there—the whole opaque lens-substance having become liquid. The foreign body moved freely around in the closed capsule, according to the position of the head, always gravitating to the most dependent part. No doubt the fluid lens-substance was gradually absorbed, and the capsule closed in more and more on the foreign body, limiting its excursions. It probably cut through the capsule and ultimately fell into the aqueous chamber. The patient suffered no inconvenience from it, except the blindness.

Some years since, a young man was brought to me suffering severely from an eye that had been injured, ten days previously, by the explosion of a mineral-water bottle, which he had been holding in his hand. He felt a sharp sting in the eye, followed by bleeding. For the next twenty-four hours he did not suffer much, and could see large objects. Severe pain then set in; sight was extinguished, and he came to me in that condition. There was a cicatrix in the lower lid, about a quarter of an inch long, just below the margin, and occupying its entire thickness. In the lower part of the sclerotic, through the ciliary region, exactly corresponding to the scar in the lid, was a penetrating wound a quarter of an inch long, with two little radiating branches. The pupil was largely dilated, and the fundus of the eye showing a marked yellowish reflex, indicating extensive suppurative choroiditis. I felt very confident that a large piece of glass was in the eye, but the turbidness of the vitreous prevented my seeing it. Enucléation was performed. There was extensive suppuration in the vitreous, extending from the sclerotic wound across the ciliary body, with neuro-retinitis in a most intense form. The optic disc was greatly swollen, completely obscuring the vessels, and presenting the characteristic appearances of neuritis; but no foreign body was found in the eye. A long, slender, wedge-shaped piece of the bottle had passed through the lid, deep into the eyeball, and had then rebounded.

The pages of our experience, written and traditional, are full of marvellous accounts of foreign bodies tolerated in the eyes for years. One instance, from my own case book, must suffice:—

An Irish stone-cutter had his left eye put out by a piece of stone. Shortly after, the right eye was injured by a knife, causing traumatic cataract. This Sir William Wilde extracted, giving the man "good sight" for over twelve years. Then iritis attacked it, producing a false membrane in the pupil so that he could not work, and in that condition he came to consult me, fourteen years after the loss of the left eye. This eye was atrophied, and on examination, a piece of stone was seen projecting from it, directly between the lids. The visible part was about one-quarter of an inch long, the end in the shrunken eye being larger than that which was seen. So the sclera was incised and the piece removed. It was half an inch long, and a quarter of an inch wide at its widest end. When the right eye had been operated on for traumatic cataract, and restored to useful sight, the left, containing the foreign body, was not atrophied, but painful. The pain persisted for twelve years, when sympathetic iritis set in, impairing, but not destroying, the sight of the right eye. Soon after this the left ball shrank, passing into the condition in which it was when I saw him. Fortunately, the sight of the right eye was such that by fitting it with a cataract glass he could see to shovel dirt, and was satisfied.

SYMPATHETIC OPHTHALMIA.—If while one eye is suffering from an injury or an inflammation, the other is attacked by disease, not fairly attributable to any other cause, we call it sympathetic. Sympathetic ophthalmia embraces a variety of lesions in different parts of the eye, all recognizing a common cause. Although traumatic inflammation of one eye is the most frequent cause of sympathetic destruction of the fellow eye, still this may arise from other troubles. The presence of a foreign body in the injured organ increases the danger to the other. The most dangerous region is the ciliary, embracing a narrow zone around the cornea. It is very liberally supplied with nerves and bloodvessels.

Dr. Alt says that seventy-six per cent. of sympathetic diseases are referable to trouble in the ciliary body of the offending eye. The iris is usually involved at the same time, a complication called irido-cyclitis. Not unfrequently, and in the most dangerous cases, the whole uveal tract and the retina become implicated. But very rare instances arise of fatal sympathetic loss of one eye, where the iris, ciliary, and choroid in the other, have not been affected. A phthisical globe, perfectly painless and free from all outward manifestations of irritation, has been supposed to give rise to sympathetic disease. In the majority of cases, however, it seems to be bony degeneration of the choroid in such stumps that finally provokes pain and irritation, and sympathetic trouble. Cyclitis, or irido-cyclitis, whether traumatic or spontaneous, seems to be the immediate provocation of sympathetic suffering. Injuries in this dangerous region, especially when complicated with prolapsus of the iris or of the ciliary body, always involve very great danger to the fellow eye. If, in addition to the wound and its complications, a foreign body is lodged in the eye, the danger is heightened. The resulting inflammation is then much harder to subdue, and returns on the slightest provocation. Even when the foreign body becomes encysted in the ciliary region, and remains harmless for many years, it is liable to be dislodged and to give rise to serious trouble in both the injured and the well eye. Accidental and surgical injuries of all kinds in this region are necessarily serious.

In the past fifteen years, numerous cases of sympathetic destruction of one eye, following a Graefe's extraction in the other, have been reported. Few operators of large experience, have been saved from this sad disaster. Worse than this has happened to me and to others:—

A few years since, I operated successfully on an eye for cataract. All went so well that, in a week, yielding reluctantly to the urgent wishes of the patient, I extracted the other lens. Fatal reaction followed; the first eye became involved in sympathetic inflammation; and the patient was left hopelessly blind.

Even iridectomy has been the cause of loss of the fellow eye, but the danger involved is excessively small.

I recall the case of a young lady who consulted me, many years ago, for a large prolapsus of the iris at the upper margin of the cornea. It had existed for years, and was the result of a perforating ulcer. Although quite large, it was covered generally by the upper lid, and the eye was useful. I clipped it off with scissors, and in a few days ugly iritis ensued, and persisted stubbornly. At length it abated, and the patient returned home to the country. Some months after, she came back with complete disorganization and blindness of both eyes. In such a case, with a prolapsus having a large neck, lined with membrane of Descemet, connecting with the aqueous chamber, and of long standing, I should be very careful.

After one of my earliest extractions by Graefe's linear method, there remained a moderate prolapsus of the iris at one angle of the incision. The lady, now over 80, has a prolapsus as large as half a grain of wheat, covered by the upper lid, causing her no inconvenience, and with a rare vision of 1.

Of course, hernia of the iris, making traction upon the ciliary and other structures, and keeping up persistent and dangerous cyclitis, may be the result of simple ulceration and perforation of the cornea, as well as of injury.

In the most serious forms of irido-cyclitis, there is one symptom of peculiar significance. I mean habitual tenderness to pressure at some particular point in the ciliary region. It is nearly always above, and can be detected by pressure with the finger through the lid, or with a probe. The moment the sensitive point is pressed upon, the patient involuntarily shrinks and complains of pain. This important and never-to-be-forgotten symptom is not always present, but when it is detected, great and imminent danger is to be feared. It oftener exists when the painful eye is blind and shrunken than when it is plump. If the local tenderness of the stump is due to bony deposits, the sensitive and very hard points are far back. But they import serious danger here as well as in the ciliary region. With this symptom of local tenderness to pressure, with more or less constant irritation of a blind eye, the surgeon should not hesitate to urge immediate enucleation.

"The following list," says Dr. Ludwig Mauthner, "comprises the sympathetic diseases of the eye: neuralgia of the ciliary nerves; irritation of the retina and of the optic nerve; functional disturbance of the retina; inflammation, severally, of the conjunctiva, cornea, and choroid; inflammation of the uveal tract, with or without participation on the part of the ciliary body, so that there may be both a sympathetic iritis and a sympathetic choroiditis, without coexisting cyclitis; inflammation of the retina, alone or in conjunction with inflammation of the choroid; inflammation of the optic nerve; glaucoma; disease of the vitreous and of the lens." It is questionable whether some of the cases reported, and from which this list has been made up, were genuine cases of sympathetic disease, or only accidental occurrences.

My limits will not admit of discussion as to the channels by which disease may extend to the fellow eye, and the mode of its propagation. The general belief is that the morbid process extends directly from the injured to the other eye, and is not the result of reflex, excito-motor influence. In addition to the route of the ciliary nerves, the frequent presence of optic neuritis or neuro-retinitis in enucleated eyes, would indicate that the optic nerve and its sheath were perhaps frequent channels of morbid communication. The sensory branches of the trigeminus, so freely distributed to the ciliary muscle, iris,

and cornea, through the long and short ciliary nerves, would perhaps account for the great frequency of sympathetic affection after injuries and diseases of those structures, especially of the ciliary region and the iris.

The fellow feeling existing between the eyes is vividly manifested, in all acute and painful affections of one eye, by the tenderness to light, spasm of the lids, weeping, and ready fatigue of the other. If this is not identical with, it is certainly very similar to, the "*sympathetic irritation*" which is so often the precursor of sympathetic ophthalmia. It is true that the early and intense suffering of one eye with the other, in the beginning of acute affections, whether of traumatic or idiopathic origin, generally subsides in a few days, while the sympathetic irritation that forebodes danger to the sound eye generally does not come on for some weeks or months; still, the persistence of the suffering of the early stage for weeks or longer, without abatement, certainly indicates quite as much danger of sympathetic loss of the sound eye. While, in either case, the irritation and functional weakness may continue for years without issuing in destructive inflammation, it is wise to act on the assumption that such danger is ever imminent. While it is undoubtedly true that neuro-retinitis may extend from the injured to the well eye, following the optic nerve through the chiasm—and that irido-cyclitis, through the ciliary nerves, often gives rise to inflammation of the same parts in the sound eye—it is certain that optic-neuritis in one eye can only excite the same disease in the other, and not cyclitis; and *vice versa*. Where the two diseases are found together in the offending eye, they may likewise be associated in the other, sympathetically. When the known conditions of danger exist, there are certain premonitory symptoms, which sometimes result in sympathetic ophthalmia in a few days, and at other times not for weeks or even months.

This warning irritation is of immense practical importance. If it is recognized, and the offending eye promptly removed, before actual sympathetic inflammation of any kind has been set up in the fellow eye, the patient is saved from blindness. The exceptions to this rule are extremely rare. In my own large experience I do not recall a single one. What then are these alarming symptoms? One of the most common, is a certain vague smokiness before the eye, with difficulty in focusing small objects. If the patient strives to read fine print, it is difficult, and soon becomes painful. The pupil is usually sluggish, rather dilated, and the patient often speaks of a wavering mist before him, like the glimmerings of a heated atmosphere. These disturbances are often periodical, and perhaps worse when the diseased eye is suffering paroxysms of pain. Tested in the usual, accurate way, the vision is below the normal. Sometimes flashes of light, changing colors, and photopsia of various kinds and degrees, torment the patient. Rarely there are extreme intolerance to light and harassing blepharospasm. These symptoms of retinal irritation are occasionally attended by concentric narrowing of the field of vision, as well as by marked dimness of direct vision. With these symptoms, there may be the faintest blush of redness in the ciliary region, but often there is none at all. Much of the indisposition to fix on and focus small objects, is due to the pain produced in the injured eye by efforts of accommodation. Should these warnings come on while the injured or diseased eye is subject to paroxysms of more or less severe pain, or if, in the absence of spontaneous pain, there should be found a tender spot over the ciliary region, danger is impending. This tender point in the useless eye is characteristic of cyclitis, and sometimes a corresponding one is found in the threatened organ. Nearly always above, it may be detected by pressure with the finger or a probe through the upper lid. The moment the sensitive place is reached, the patient winces. In cases of quiescent atrophy of the

globe, dating back many years, ossification of the choroid, or calcareous degeneration of the lens, may at length give rise to pain, tenderness, and sympathetic danger. The shrunken stump then becomes hard and painful to the touch, especially posteriorly.

I recently removed such an eye from a gentleman, fifty years old. It had been put out by a pen-knife in boyhood, and never gave the least discomfort till within the past two years. It then grew painful and tender to the touch, and gave rise not only to sympathetic irritation in the sound eye, but at times to excruciating attacks of facial neuralgia, and to falling fits of unconsciousness. All these symptoms disappeared when the eye was enucleated.

An eye, whether plump or shrunken, that contains a foreign body, is always liable to become troublesome and dangerous to its fellow.

How long after the injury does it require for sympathetic ophthalmia to be set up? I have known it to be developed in three weeks. Mauthner never saw it occur sooner than four weeks. The interval may vary from three weeks, which seems to be the shortest time, to months, and even to forty or fifty years, as in the case above cited. The reported cases of neuro-retinitis and other forms of sympathetic ophthalmia, coming on in a few days after enucleation, were not caused, as alleged, by the enucleation. The diseased process was on its way around, before the operation, and would probably have broken out at the same time, had nothing been done. It is hard for me to believe that the contusion of the optic and ciliary nerves by the scissors, in enucleation, could produce sympathetic disease. At least, I have had the good fortune to be spared seeing such cases. That traction on, or constriction of, the optic nerve, after enucleation, may excite to sympathetic irritation, was, however, demonstrated by a case of my own:—

I had enucleated the painful eye some months before. The patient returned, complaining of harassing photopsia, glimmering, and tenderness to light, so that he could not apply the sight of the eye. All these symptoms were at once relieved by a little leather pad, pressed firmly back into the hollow socket by a bandage, which he had worn for weeks. By an operation, in which a piece of the nerve stump was detached and removed, all trouble ceased. Such cases have been reported by others.

That similar disturbances might result from cicatricial compression of the ciliary trunks, I can believe. Under all the circumstances, where sympathetic inflammation of the good eye has been observed, and with the premonitions of sympathetic irritation, eternal vigilance is the price of sight.

By far the most frequent form of sympathetic inflammation, is irido-cyclitis, extending in the worst cases to the choroid. Beginning usually with the symptoms of an ordinary acute or subacute iritis, but resisting all treatment, and leading to firm agglutination of the entire iris to the capsule of the lens, it results at last in hopeless disorganization. Cyclitis, with tenderness to pressure, softening of the globe, and slow but fatal extinction of vision, follow in the train. Sometimes encouraging remissions will be seen, but soon the turn comes and all is lost. In the simple form of serous iritis, sometimes seen, enucleation is not necessary, as the disease may be controlled without. In the plastic and malignant variety, most often witnessed, enucleation does no good, and may often do harm.

But in other forms of sympathetic manifestation, especially those showing neuro-retinitis, it would seem as though enucleation exercised a favorable influence. Watchful anticipation and prompt surgical interference, before or as soon as the ominous sympathetic irritation has set in, is the only sure and safe treatment. Whenever a hopelessly blind eye is, and perhaps has long been, comfortable, with no local tenderness to pressure, and when the

other eye is perfect, with no evidences of sympathetic irritation, it is useless to mutilate the patient out of foolish fear of danger. On the other hand, even a partially seeing eye, after an injury, should be sacrificed without hesitation if alarming symptoms of danger to the other eye have set in.

In destructive injuries of the eye, with evidences of a concealed foreign body, or even without, it is often a wise precaution, to enucleate as soon as possible after the fatal injury, before violent reaction has set in. In that way the patient is saved from protracted and severe suffering, as well as from danger to the fellow eye. But even after severe panophthalmitis has set in, in case tenderness to light, cloudiness of vision, glimmering, and other alarming symptoms are developed, I should resort to removal of the offending eye. I have done it several times, with none of the fatal consequences described and feared by Von Graefe and so many others. While I would warn against the extreme view that every blind eye, whether from disease or injury, ought to be enucleated, and that any trouble that comes to the fellow eye is presumably sympathetic, I would still emphasize the fact, that *any blind eye*, at any time *may* become a source of risk. This is particularly true if an artificial eye is worn over an old, atrophied globe, especially one in which the cornea is preserved. Even after enucleation, the wearing of an artificial eye has, in rare cases, given rise to sympathetic developments that have subsided soon after discontinuing its use. In many hundred cases I have never seen this result, nor have I ever lost a patient from the removal of the eye.

The operation of enucleation is very simple. The instruments required are a pair of strabismus scissors (Fig. 936), one or two strabismus hooks (Fig. 935), a pair of toothed forceps, a stop speculum (Fig. 921), and a pair of stout, blunt-pointed scissors, curved sharply on the flat. An assistant must be ready with a few soft, clean sponges. As to anæsthetics, I generally give them, but often operate without, where the patient prefers it and has good self-control. The operation is a little more tedious and painful than a tenotomy, but can be easily borne without ether. The patient, whether under ether or not, should lie on the back and be kept quiet if possible. The speculum introduced, the conjunctiva is seized near the cornea, raised, and rapidly divided close around the cornea. After the first incision a strabismus hook may be passed rapidly round the cornea under the conjunctiva, raising and making it tense so that the scissors may divide it regularly and quickly. This done, the forceps pick up the conjunctiva above, while the scissors detach it over the insertion of the superior rectus. The hook is slid under and the tendon severed close to the sclera. The same is then quickly done for the three other recti tendons. The speculum is now removed, and the eyeball sprung between the lids, which are pushed back. If any trouble is experienced in this manœuvre, it is due to the fact that a tendon may partially or completely have escaped division, or that the globe is too large to pass the commissure. In the latter case, the stout, curved scissors, closed and passed behind the globe, may aid in prying it forward. This done, the index finger of the left hand is passed in behind the globe, springing it more forwards, and rendering the optic nerve tense. The nerve is thus felt and held securely by the index finger which guides the scissors, introduced from the opposite side. They are passed in, closed, till the point is felt by the finger. Then opening and pushing them a little further, the nerve is snipped off between the finger and the sclera. It is hardly possible in this way to fail in severing the nerve at once. It yields with a jerk, and the ball, coming forwards, is seized by the left hand, drawn out, and the two oblique muscles detached with the scissors, using great care not to cut the lids in this last act. The moment the eye is removed I plunge the left index to the apex of the orbit, and make rather firm pressure

for a few minutes, stopping the hemorrhage at once. That done, a folded wet compress is placed over the closed lids, and a bandage tightly applied. Usually the loss of blood is next to nothing, and I have had serious hemorrhage in but two cases. These were both in old people, and in both the bleeding was readily controlled by the finger passed firmly into the orbit. No sponge, cotton, or anything but the finger, should ever be inserted into the orbit.

TREATMENT OF WOUNDS OF THE EYEBALL.—An incised, or even a lacerated wound of the *conjunctiva*, alone, very soon heals. When it is extensive, the edges should be well united with stitches. Even when a considerable portion is carried away, it slides and stretches so readily that the denuded surface is easily covered, as is done after the removal of a pterygium. The operation of syndectomy (removing a large zone of conjunctiva from the eyeball, immediately around the cornea), sometimes practised for the relief of obstinate pannus and other diseases of the cornea, shows how extensive a surface may be covered in this manner. The same is true of the extensive removal of the reflected portions of the conjunctiva, as a mode of treating granular eyelids, gravely proposed and executed by a French oculist. I cannot believe, however, that such operations are justifiable, knowing the many disadvantages which result from the great contraction of the conjunctival surface that must follow. The restraints in moving the eyes resulting from the marked symblepharon, and the inevitable dryness from impaired secretion, are not compensated for by the ends obtained. All surgeons know the serious and incurable lesions of the conjunctiva and lids, resulting from destruction of granulations by caustics. These facts should guide us in saving all the conjunctiva possible in wounds and burns of that important membrane. Very serious after-effects may follow wounds and losses of conjunctiva at the inner commissure of the lids. The cutting off or tearing away of a canaliculus by a wound, gives rise to the most troublesome and often hopeless weeping, so that, if possible, this complication should be recognized and overcome by careful use of stitches, so that the permeability of the canaliculus may be restored. Burns in this region, for the same reason, are very serious, and often lead to epiphora, entropium, trichiasis, and an endless train of troublesome consequences. Indeed, burns of the eye and lids, especially when extensive and deep, are most disastrous. The reaction follows very slowly, so that the prospects at first look hopeful; but in a few weeks severe and persistent inflammation sets in, leading to uncontrollable adhesions between the lids and the ball, to opacities and perhaps perforation of the cornea, and to other lesions. One cannot be too guarded in the prognosis of such cases. Consequences inevitable from the first, are apt to be put down to the credit of faulty treatment. Wounds of the conjunctiva, when properly dressed, need no local remedies but weak detergents. No astringents or painful applications must be allowed. Of course, conjunctival wounds often exist as an important complication of other deeper and more serious injuries, which then command the chief attention. If a muscle be severed, or the sclera penetrated, or if a deep wound of the socket be present, these become objects of solicitude. Should a foreign body hang in the conjunctiva, or be lodged under it, diligent search must be made in order to its speedy removal. Sometimes, when a small piece of steel or other substance has passed under the conjunctiva, it can only be removed by firm seizure with forceps and snipping away a small portion of the membrane with it. Should a wound of the conjunctiva exist with a more or less serious injury of the lid or lids, the proper and exact adjustment of the margins of the wound is the chief point to be secured. The presence and seat of a wound of the lid, or its entire absence,

are often valuable aids in the diagnosis and treatment of injuries of the eye, of whatever kind.

The treatment of injuries of the *cornea* depends much upon the complications. If perforation have not occurred, and the wound be not contused, simple cleansing, followed by quiet, closure of the lids, and cold applications, or a comfortable bandage for a few hours or days, is all that is required. If the chamber has been opened, the sudden spirting of aqueous will nearly always produce hernia of the iris. This should be reduced, if possible, but it can only be done during the first few hours. Plastic exudation soon takes place, and so glues the protruding iris in the wound that it cannot be returned. If the prolapsus is small and quite recent, involving only a small portion, if any, of the pupillary margin, the prompt and energetic use of eserine may reduce it completely. Rarely is it safe or advisable to try to return it by a spatula or other instrument. If the herniated iris cannot be relieved, the next best thing is to remove as much of it from the wound as possible. This requires much delicacy and coolness on the part of the surgeon. If the patient has great self-control, anæsthesia is not required, but otherwise it must be complete. If the prolapsus is at all prominent, it can be clipped off with scissors pressed well against the cornea. If ever so little of the pigmented iris is snipped away, the aqueous trickles or spirts out, and the prominence at once disappears. Should this plan not succeed, the imprisoned iris must be seized with small iris forceps, drawn gently and carefully out, and snipped close to the corneal surface with the scissors. Great caution is here required in preventing any sudden rotation of the eye, which is almost certain to occur if the patient be not unconscious. The iris is most acutely painful when seized, and, if the patient roll the eye suddenly, the whole or a large part of this membrane may be dragged loose from its insertion. Von Graefe relates a case in which the entire iris was removed from the eye by such an accident, and I have seen such an occurrence in other hands. When the eye is perfectly still, and the iris is drawn tense, and snipped quickly and close, no such accident can take place. It is of vast importance for the future of the eye, to remove every trace of iris from the wound. Otherwise, staphylomatous protrusion of the cornea, glaucomatous hardness, and slow but hopeless loss of vision may be the result. If with the corneal perforation and hernia of the iris, there be, at the same time, injury of the *lens capsule* and cataract, the danger of violent reaction is greatly increased. The rapid swelling of the traumatic cataract leads to pressure upon the iris, increased intra-ocular tension, pain, and perhaps panophthalmitis. The first thing to be done is to free the corneal wound from iris, as above directed, and then to dilate the pupil and keep it dilated by instillations of atropia, four grains to the ounce of water, dropped in several times a day. The dilatation draws the pupil away from the irritating lens substance, and helps to control iritis and the tendency to closure of the pupil. If the lens swell so rapidly that large masses protrude through the rent in the capsule, it may be best to remove it by a linear incision in the cornea, or by opening, and perhaps enlarging, the original corneal wound. But if the patient is young, the absorbents active, and the pain and increase of tension not great, this may not be necessary. In that case, or after removal of all the soft lens substance that can be readily let out, the patient should be put quietly to bed, and ice-cold compresses, renewed often and kept up day and night, should be used till the reaction is controlled. It is next to certain, however, that at best the eye will recover with secondary cataract, adhesions of the iris, and little or no useful sight. But the patient is saved from protracted suffering, hopeless loss of sight, and the danger, immediate and remote, of sympathetic ophthalmia in the other eye. By prompt and skilful treatment, an eye may be saved and made useful at a later period by an iridectomy. Of

course, if with all the lesions already described, a foreign body be lodged in the lens, it must be removed with as much of the lens as possible. If an iridectomy can aid in its removal, this should be employed, and will, perhaps, help to save the eye. Should the foreign body have traversed the lens and lodged deep in the eye, it cannot be removed, and the sight will be lost, with great danger of sympathetic trouble in the fellow. In such a case, immediate enucleation may be advisable.

If a limited contusion of the cornea, without perforation or rupture of the globe, has occurred, the immediate reaction may be slight, but very destructive consequences are likely to follow.¹

Wounds of the cornea proper are not as dangerous to sight, even with the serious complications mentioned, as injuries of the same kind at the *sclero-corneal junction*. If the aqueous and vitreous chambers have both been opened, there will not only be loss of vitreous and perhaps intra-ocular hemorrhage, but prolapsus of the iris and of the ciliary circle. A careful removal, if possible, of any foreign body from the wound and the eye, must be followed by snipping the iris from the corneal wound, and clipping off the protruding vitreous, so as to secure the very best coaptation. It is seldom advisable to use a stitch except for the conjunctiva. If extensive wounds of this critical region be complicated by intra-ocular hemorrhage, and the presence of a foreign body that cannot be reached, immediate enucleation is the shortest and safest way out of difficulty. Lately, a few successful cases have been reported of removal of pieces of steel from the eye by aid of a magnet. In the great majority of instances this plan fails, but it is sometimes worth a trial. In wounds of the *sclera*, not involving the ciliary region, a stitch or two, embracing the ocular conjunctiva and the superficial tissues of the sclera, may be resorted to with advantage. In extensive rupture of the sclera, parallel to the corneal margin, with perhaps complete loss of the lens and escape of vitreous, little can be done but to cleanse the wound and apply a bandage for a few days or weeks. Such ruptures are not apt to be followed by violent reaction or sympathetic danger, and sometimes get well with useful vision. If the lens has escaped and lodged under the conjunctiva, this membrane must be incised and the lens removed. In case of *concussion of the eye*, without rupture or wound, the lens may be luxated, and may become, as it nearly always does, a serious source of irritation and danger. If it has been knocked through the pupil into the anterior chamber, it must be carefully extracted. If displaced to one side, behind the iris, it is very liable to give rise to irritation and secondary glaucoma, with pain and total blindness. In that case, if it cannot be safely extracted, the eye should be enucleated in order to save suffering and place the other eye in a condition of safety. An operation for the removal of such a lens involves grave difficulties and risks. Still, it can sometimes be successfully done, and the eye saved. Should a small *foreign body*, driven with force, penetrate deep into and remain in the eye, with only partial impairment of sight, what is the wisest course to pursue? If it cannot be removed by the magnet, it may be safe and wise to keep the patient quietly under observation for some weeks or months, to see if it will be tolerated. It may become encysted in the vitreous, retina, or choroid, and may remain harmless. But such eyes are always a source of solicitude to the experienced surgeon, and may suddenly develop trouble, at any time. If fixed in the ciliary region, the foreign body will almost certainly give rise to inflammation and sympathetic danger. When forbearance ceases to be safe for the patient, enucleation must be resorted to.

Of all foreign bodies lodged in the eye, a shot is more likely to remain

¹ See hypopium keratitis, page 620.

harmless than anything else. I recall three cases in which both eyes were destroyed by shot. One patient had extensive intra-ocular hemorrhages, followed by cataract, but never suffered any severe pain, and the eyes were preserved with a plump, healthy appearance. The second patient I saw but once, and never heard of afterwards, while the case of the third presented some interesting features:—

A boy, 12 years old, received a discharge of bird shot in the face, and was instantly blinded. The accident occurred September 29, 1881, and I saw him one week afterwards. A shot had penetrated the right eye through the ciliary region, near the inner margin of the cornea. In the left, another had entered through the cornea, near its edge, and had traversed the iris and lens, producing traumatic cataract. The lens was finally absorbed, leaving a clear pupil, with some vision, and perception of colors. The eye is normal in size, tension, and appearance. In the right, chronic cyclitis and atrophy of the globe followed. But this eye, even, is now quite comfortable.

If a shot has entered the eye anywhere in front of the equator, the round discolored point of penetration can always be detected. (Plate XXVII., Fig. 6.)

Concussion of the eye often leads to serious and permanent injury to sight. In many cases, rupture of the lens capsule is detected, and of course traumatic cataract follows. In others, no rent in the capsule can be discovered, but cataract ensues, probably from loosening of the lens from its intra-capsular connections.

In other instances, no gross lesions can be discovered to account for the damaged sight. There must be some molecular disturbances in the rods and cones, but they are not appreciable by the ophthalmoscope. Sometimes hemorrhages into the vitreous are found, and not infrequently genuine ruptures of the choroid. These are usually crescentic in shape, with concavity towards the optic disk. (Plate XXVIII., Figs. 1 and 3.) These lesions are always connected with serious damage to vision, from necessary injury to the percipient elements of the retina. The rule is that suppurative inflammation follows the penetration of a foreign body, whether the latter lodge in the eye or not. In rare exceptions little inflammation ensues, and in some none at all. Why this great difference, in apparently the same circumstances? It has usually been attributed to difference of individual toleration, due to temperament and idiosyncrasy.

In the recent researches of Lebert and others, the germ theory seems to afford an explanation. By experiments with animals, and observations drawn from large numbers of published cases in men, he has come to the following conclusions: (1) The simple presence of a pure and chemically indifferent foreign body in the eye, excites no inflammation. (2) Aseptic foreign bodies, of metals which oxidize, do not give rise to suppurative inflammation, but cause trouble, especially when large and in the vitreous, giving rise to detachment of the retina, etc., from chemical reactions. (3) Suppurative inflammation always follows, if the wound is infected by germs of lower organisms that rapidly multiply in the wound and around the foreign body. Suppurative inflammation can come from chemical irritation, but if no germs are present, usually does not. (4) The suppurative inflammation, after injuries, from the growth of microbes, is caused by the chemical substances eliminated by their growth, as is the inflammation complicating cysticercus cellulosa in the eye. The chemically indifferent foreign bodies, are particles of stone, glass, splinters of wood, eyelashes, gold wire, and lead, when free from germs.

In a brief note just published, Lebert adds the following: (1) Aseptic pieces of copper, unlike those of iron and steel, when lodged in the anterior

chamber, excite suppurative inflammation only when in contact with the iris, but not when sticking in the lens, and projecting into the anterior chamber. (2) If the piece of copper is suspended in the vitreous humor, suppurative inflammation does not follow. When resting in the tunics of the eye, in the ciliary region, suppuration ensues, but is limited to the immediate neighborhood of the foreign body. (3) Lead wire does not excite suppuration, either in the vitreous or in the anterior chamber. But small masses of lead, suspended in the vitreous, give rise to the same form of detachment of the retina as iron or copper. (4) Metallic mercury, introduced aseptically, develops, both in the vitreous and anterior chamber, severe suppurative inflammation; but this differs from the inflammation produced by rapid germ development, by not extending to the neighboring parts of the eye. These results refer, of course, to experiments on the eyes of animals.

DISEASES OF THE CONJUNCTIVA.

The known frequency of these affections is in part explained by the constant contact of the air, and of all it contains, with the conjunctiva. Not only floating particles, but poisonous vapors thus reach its sensitive surface, and give rise to irritation and inflammation. The easy access of contagious secretions, also, gives a rational explanation of the origin of many of these maladies, while the influence of atmospheric changes in exciting diseases of this portion of the mucous membrane, is likewise well established.

CONJUNCTIVITIS.—By far the greater number of morbid processes involving the conjunctiva are of an inflammatory character, and we naturally begin, therefore, with the *symptoms* of conjunctivitis, and first, the *objective symptoms*. These are: (1) Increased injection, ranging from the slightest blush to the most vivid redness. (2) Swelling, due to inflammatory hyperæmia and infiltration of the tissues, but more especially of the subconjunctival structures. High degrees of this swelling, when involving the ocular conjunctiva, are called *chemosis*. Chemosis may be *serous*, of a watery appearance, yielding readily to slight pressure, and indicating less severity of inflammation; or *phlegmonous*, firmer, more opaque, tenderer to pressure, and evidencing more violent inflammation. (3) Perverted and increased secretion. This change varies from a slight excess of transparent mucus, through the muco-purulent form, to the most marked and profuse purulent discharge. The mild forms of conjunctivitis are usually transient, and attended by little danger. The phlegmonous and purulent varieties are apt to be disastrous in their consequences. They are, however, but degrees of the same process.

The *subjective evidences* of conjunctivitis are, a sense of dryness, itching, burning, and a feeling of sand in the eyes. Severe pain is not present except in violent forms of the disease, and then arouses fears of trouble in the cornea or the iris. Cloudiness of vision, and rainbow-colors around objects, are due to flakes of mucus on the cornea, and disappear by washing the eyes. Constant deficiency of sight generally results from morbid changes in the epithelium or other structures of the cornea.

The *diagnosis* of conjunctivitis is very easy, but the ready recognition of serious complications is not so simple. Therein are manifested the skill and success of the expert.

Prognosis.—The tendency of conjunctivitis, as of most other diseases, is to recovery. Under favorable circumstances it is apt to get well spontaneously. Aggravated by injudicious treatment or bad surroundings, or both, it becomes tedious and dangerous to sight. When recovery is spontaneous, or

hastened by mild treatment, the conjunctiva is restored to its physiological condition, even in the most alarming, purulent form of the malady. As far, then, as the integrity of the membrane itself is concerned, the prognosis is always favorable. It is only in chronic cases, complicated by granular lids, that serious lesions of the conjunctiva itself are produced. The dangers of conjunctivitis are, immediately, to the cornea and iris, and, remotely, that of the formation of granulations and of their endless duration and consequences. The things to be most feared in every case of severe or protracted conjunctivitis, are implication of the cornea and more or less serious damage to its transparency.

Varieties of Conjunctivitis.—The marked characteristics of some forms of conjunctivitis have led to their separation and special designation, under the names of *simple*, *catarrhal*, *purulent*, and *phlyctenular conjunctivitis*. The first is mild, of short duration, attended by little secretion, and causing but slight inconvenience. The second is more serious, lasting longer, giving rise to more annoyance, and being attended by greater secretion of mucus. The third is the most acute, painful, and dangerous to the integrity of the eye, its diagnostic symptom, indicated by the name, being a profuse discharge of pus. A form of purulent conjunctivitis rarely seen in this country, but very destructive to sight, is called *diphtheritic*. In it there is at first no purulent discharge, but a plastic infiltration of all the tissues, strangulation of the blood-vessels, and usually destruction of one or both corneæ. *Croupy* conjunctivitis, where the deposit is superficial, and can be peeled off, is much less serious. The *phlyctenular* variety is limited to definite parts of the conjunctiva, and, as the name implies, is known by the formation of little elevations or phlyctenulæ, the favorite seat of which is the ocular conjunctiva, near the cornea. They vary in number from one or two to many more, in bad cases surrounding the entire cornea. Each is a focus for well-defined local injection, the rest of the membrane often being quite free from redness. In the mild cases there is little secretion and no intolerance of light. When the isolated phlyctenulæ are more numerous, the patches of inflammation become confluent, the secretion of mucus is more free, and the symptoms are those of acute, catarrhal conjunctivitis. The diagnostic lesion is the well-marked phlyctenula. This peculiar inflammation occurs nearly always in children with the scrofulous diathesis. The same little patients often suffer at intervals with blepharitis ciliaris, scabby eruptions in and around the nose, on the skin of the lids, behind the ears, and on the scalp, with enlarged lymphatic glands, hypertrophied tonsils, and other strumous manifestations. The disease seldom occurs in adults, except in such as have had it, at times, from childhood. When the phlyctenulæ are seated on the cornea, they give rise to more serious and protracted suffering, and often leave the eye damaged in sight from corneal opacities. The disease is then called phlyctenular keratitis, but it differs in nothing, save in the seat of the lesion, from phlyctenular conjunctivitis. The chief disease of the eyes in infancy is purulent conjunctivitis; that of childhood, phlyctenular conjunctivitis. The healthiest infant may have the one, but only the scrofulous child the other.

Etiology of Conjunctivitis.—It would seem that all the varieties just described may recognize the same causes, the very different symptoms depending on the peculiar constitution of the patient, his immediate surroundings, or a difference in the directness and intensity of the cause. For instance, a catarrhal conjunctivitis, due to atmospheric causes, may be aggravated by bad ventilation, filthy habits, and constant reckless exposure, into the purulent form, with its destructive tendencies. On the other hand, the simple, the catarrhal, and the purulent varieties, may often be traced to the same contagion. Atmospheric vicissitudes acting on a strumous child, will probably

give rise to phlyctenular conjunctivitis, while in the adult and non-scorfulous, the catarrhal variety will follow; or if the cause act with sufficient intensity, aggravated by bad health and surroundings, purulent conjunctivitis may result, with all its characteristics. While these are established facts, doubtless by far the most frequent cause of purulent conjunctivitis is contagion. To the eyes of the infant it comes from the genital organs of the mother, during parturition. In the adult, it is the result of self-inoculation with gonorrhœal matter. The contagion may get into both eyes at, or about, the same time. But frequently the second eye contracts the disease from the secretions of the first. Without careful supervision this is almost certain to occur, when only one eye is at first involved. To prevent inoculation of the second eye from the first attacked, is much more difficult in infants than in adults. Because an infant is attacked by severe purulent conjunctivitis soon after birth, we are not justified in assuming, necessarily, that the mother has gonorrhœa. Simple leucorrhœa, the lochia, and even the liquor amnii, getting into the eyes, may give rise to purulent conjunctivitis. Certain atmospheric or other conditions sometimes predispose to the more ready and rapid spread of the contagion of this disease, causing it to assume an epidemic form. At such times, it is not always easy to trace the contagion where it actually has taken place; and sometimes inflammatory conjunctival diseases arise without contagion, and, when reaching a certain suppurative degree, are communicated to others. In badly ventilated asylums, school-houses, barracks, and tenement houses, where large numbers of persons are crowded together, especially at night, the conjunctiva becomes so irritable, and takes on violent disease from such slight causes, that the destructive spread of conjunctivitis can only be prevented by breaking up the dens of infection, and isolating the diseased persons. Isolation, cleanliness, fresh air, and healthy food must be secured, if the disease is to be cured or prevented from spreading.

Ophthalmia neonatorum, the scourge of the lying-in room in all ages, is now so well understood by educated physicians, that its occurrence can be nearly always prevented by timely precautions. I have insisted for many years, in my lectures, on the importance of promptly washing off the face and eyelids and washing out the eyes of every new-born babe, with clean tepid water, before bathing its body. The additional precaution of dropping a solution of nitrate of silver into the eyes, twice a day, for the first day or two after birth, will certainly save the child from purulent conjunctivitis, and from possible blindness of one or both eyes. A two-per-cent. solution is quite strong enough, and causes, even when freely dropped into the eyes, no serious irritation. A weak solution of carbolic acid, or a stronger one of boracic acid, will answer the same purpose, but the nitrate is found to be the surest preventive. The adoption of these wise precautions in most hospitals and lying-in establishments, has recently settled beyond cavil the preventability of this dangerous affection. The same remedies, at once applied, in adults where known contact has taken place by accident or carelessness, will remove or destroy the virus, and save the eye from a frightful attack of purulent conjunctivitis.

Treatment of Conjunctivitis.—Remembering the tendency to spontaneous and safe recovery in mild cases, and the great danger of inflammation of the cornea and damage to sight in severe attacks, our therapeutics will be rational. In times past, when every inflammation of the eyes was "sore eyes"—and when nitrate of silver, in substance or strong solution, was the invariable remedy—the doctor with his *lapis infernalis* was dreaded as the fiery fiend, ready to burn out the eyes! and he seldom failed!

In slight forms of *catarrhal conjunctivitis*, a few days of rest in a well-ventilated but sufficiently warmed room, some restriction of diet, gentle laxatives,

and occasional bathing of the closed eyes with fresh, cool water, even without any topical treatment with astringents, will lead to a cure. If there is much secretion, and gluing of the eyelids during sleep, a little pure vaseline, fresh butter, or lard, rubbed on the lids at bedtime, will add much to the patient's comfort. In addition, a solution of five grains to the ounce, of boracic acid or baborate of sodium, dropped freely into the eyes, night and morning, will expedite the cure. A very weak solution of other astringents, such as sulphate of zinc or copper, or nitrate of silver, one-half grain to the ounce, used in the same way, will hasten recovery. If, in spite of this mild and proper treatment, the disease persists beyond a few days, with sponginess of the conjunctiva, and more free secretion of mucus, the carefully everted conjunctiva may be quickly and lightly brushed with a solution of five grains to the ounce, of nitrate of silver, immediately washed off thoroughly with cool water. The crystal or solution of sulphate of copper may be used in the same way. This brushing should not be applied more than once a day, and with great discrimination, keeping up the milder applications in the intervals. As the symptoms subside, the remedies should be applied more lightly and less frequently, till the patient is quite well. Of course, reading or close use of the eyes, or exposure to wind, dust, smoke, and such irritants, must be forbidden. There is a form of hyperæmia of the conjunctiva, but generally with little or no secretion, which persists in a chronic way, and which is not improved, but aggravated, by astringents, strong or weak, and which is often treated by inexperienced persons as granular lids. It is the congestion due to necessary strain of the accommodation in hyperopic and astigmatic patients. Correct this strain by the use of appropriate glasses, and the conjunctival redness disappears spontaneously. This probable complication, in the treatment of all chronic, persistent cases of conjunctivitis or of blepharitis, should never be forgotten.

The local treatment of *phlyctenular* or *strumous conjunctivitis*, is the same as that already described, with the addition of certain mercurial applications known to have a happy effect in dissipating the phlyctenulæ. A little pure and finely powdered calomel may be dusted upon the eye once a day, bringing it in contact with each phlyctenula if possible. A dry camel's hair brush may be dipped into the powder, and a little quickly sent into the eye by tapping the brush with the finger. The surgeon will soon learn the knack of doing this before the patient can wink. The same thing may be accomplished by using a salve once a day. One grain of calomel with a drachm of vaseline or lard, well rubbed together, causes very little irritation, when a small piece from the end of a probe is put in the eye by everting the lower lid. The dust or the salve should be used once a day, and continued for some days after the phlyctenulæ have vanished, to prevent the formation of others. Relapse is the tendency in this disease, and can only be permanently overcome by the use of constitutional, antistrumous remedies. Quinine in tonic doses, iodide of iron, the hypophosphites, cod-liver oil, good nutritious food at regular meals, great attention to the skin, and daily out-door exercise in the pure air, kept up faithfully for months, and even years, will not only help to cure the disease, but will fortify the little patient against many others of the same fatal class.

Treatment of Purulent Conjunctivitis in Infants.—No disease yields more readily to prompt and judicious treatment than ophthalmia neonatorum, and none is more dangerous to sight when neglected or badly treated. Constant cleanliness, day and night, must be observed throughout. The irritating pus must not be allowed to stand in the eyes, but must be frequently removed with great gentleness, so as not to scratch or abrade the corneal epithelium. No syringing is safe for the eye or the operator, and the eyes should not

often be wet or washed with water. Absorbent cotton furnishes by far the best means of mopping and cleansing the eyes. The lids should be gently but well separated once an hour, or oftener if the secretion be excessive, and the matter that escapes should be rubbed off with the cotton and thrown into the fire. This can be so lightly done as not to waken the infant, and the treatment must be rigidly kept up as long as the purulent discharge persists. Two or three times a day, the eyes should be well washed with tepid water. Infants are extremely sensitive to cold water. At each cleansing, or at least once an hour, a few drops of a solution of boracic acid, five grains to one ounce, should be dropped into the eyes, and the lids drawn open so that it may reach the whole suppurating surface. It causes little or no irritation, acts as an astringent, and perhaps destroys the micrococci and their germs. An equally safe and still more efficient remedy is the nitrate of silver, half a grain to one ounce, used with the same thoroughness and frequency. A solution of alum, one grain to one ounce, may be applied in the same way. Once a day, after the suppuration is frankly established, I evert the lids fully and carefully, and pencil them with a solution of nitrate of silver, from five to ten grains to one ounce, taking great care to prevent its running over the cornea. When the lids are everted and held securely, their natural spasmodic closure will fully evert the retro-bulbar folds, and will protect the cornea from the contact of the fluid. Waiting a second or two till the brushed surface becomes whitish, tepid water must be freely used to wash off the excess of fluid before returning the lids. In this way no harm can come to the cornea, and the suppuration can be very promptly and rapidly controlled. I always expect the child to be brought back the next day after the first brushing, very much better. Once a day is usually often enough for this treatment, keeping up the cleansing and use of weak washes in the intervals. But even with simple cleansing and the daily brushings, without any other medication, these cases get rapidly well in from one to three weeks. I cannot recall a single case in which ulceration and serious damage to the cornea have ever been witnessed, under this course of treatment, when the cornea has been intact at the beginning. Whatever theory may be adopted as to the pathology of this affection, all who have tested the nitrate-of-silver treatment fairly, agree as to its efficacy. Purulent conjunctivitis is a self-limited disease, but persists much longer under cleansing and milder treatment than under that which I have advised. As danger to the cornea exists during the whole suppurative period, the more quickly it is cut short, the sooner is the danger over. As the swelling and suppuration subside, the intervals between the pencillings may be prolonged. Firmness, but delicacy, of manipulation, in everting the lids and in safely applying the remedy, can only be acquired by experience. The child should be laid backwards across the nurse's lap, with its head held firmly between the surgeon's knees, face upward, the water, medicine, and all the needed implements being at hand. No instrument is required to evert the lids.

Treatment of Purulent Conjunctivitis in Adults.—It will be admitted, I think, that with the same management, or mismanagement, a larger number of adults than of infants will be blinded by this disease. The older and more decrepit the subject, the greater the danger to the cornea and to sight. With grown persons, I insist that they shall be put to bed and kept there till well. In the very onset of the disease, I begin the constant use of iced compresses. These must be changed, day and night, every ten or fifteen minutes, and continued till the pain, soreness, swelling, and violence of the disease are under thorough control. Then they may be intermitted for a few hours in the day, and in the night. Constant and careful removal of the matter from the eyes, as with infants, is of the greatest importance. As soon

as the suppuration is fairly established, a weak solution of boracic acid, or of nitrate of silver, the same as in infants, should be freely dropped into the eyes every hour or oftener. If there is great phlegmonous swelling of the lids, chemosis, and dangerous pressure around the cornea, the external commissure of the lids may be freely divided, and light scarifications of the conjunctiva resorted to. Leeches to the temple or side of the nose may be ordered, but their effect is too slow to be greatly relied upon. The free incision of the commissure takes the blood more quickly, and directly relieves the pressure of the lids on the chemosed eyeball. A free purgative in the beginning, some restriction of diet, and opiates to relieve pain and promote sleep, are usually required. In the course of a few days, when the swollen lids and eyes are not so very tender to pressure, and the lids can be fully everted without much suffering, especially if the suppuration be profuse, the lids should be turned and pencilled once a day, as in infants. But while in the latter this may safely be done from the start, in adults we must wait a few days for the above changes to take place; then this more heroic local treatment is safer, rapidly controlling the disease, and abridging the period of danger.

CONJUNCTIVITIS GRANULOSA; GRANULAR LIDS; TRACHOMA.—Any one of the forms of conjunctivitis which have been described above, becoming chronic, is liable to lead to anatomical lesions of the conjunctiva, which, in general terms, are called granulations. In isolated cases, but chiefly in epidemics of conjunctivitis, these exuberant products are rapidly developed with very acute manifestations. The acute stage subsiding after a few weeks, the case runs on in a subacute and persistent form, and the granulations become the chief cause of danger, as well as the endless aim of treatment. An attempt has been made by Saemisch and others to establish an anatomical classification—*conjunctivitis folliculosa* and *conjunctivitis granulosa*—the former disappearing completely under mild, careful treatment, leaving no cicatricial lesion behind, and the latter always followed by more or less alteration in the anatomical texture of the conjunctiva. While it is true of rare forms of so-called follicular conjunctivitis, that they recover with perfect “*restitutio in integrum*,” the two varieties are nearly always mixed, and the prognosis, therefore, is usually not so favorable. The distinction is further based upon differences in the distribution of the inflammatory infiltrations, the follicular being grouped in closed capsules under the epithelium, or else the lymphoid elements forming in groups without a limiting membrane. In the other, the *true* granulation, the elementary products are more diffused, and pervade the deeper textures. Microscopical anatomy may finally, with further investigation, become a basis of classification and an aid in treatment, but practically I agree with Goldzieher that “*conjunctivitis granulosa*” may be held to include all varieties, as they require the same treatment. In view of the fact that they are all contagious, very tedious in duration, and prone to frequent acute relapses, that they usually lead to permanent cicatricial changes in the conjunctiva and lids, and that they seem to yield best to the same course of treatment, I shall consider them all together.

Granular eyelids are the uniform result of conjunctivitis of some kind, either acute or chronic. Hence their etiology is that of conjunctivitis. There does not seem to be any specific granular virus, conveyed by contagious secretions, producing always the same condition, and spreading in no other way. Atmospheric changes, and anything that gives rise to colds, may be followed by conjunctivitis and granulations. Morbid secretions, either from diseased eyes or from the urethra, are the most frequent means of propagation, their greater or less purulence giving them more or less virulence.

Granular eyelids are the scourge of some countries, while in others they

are scarcely known. The disease has made serious ravages in Belgium, Italy, and other countries of Europe, since its general introduction by the return of the French army from Egypt. Still, it has prevailed more or less extensively in most countries, before and since that event. It is much more likely to spread among the poor, and those whose habits are not cleanly, especially if they work hard and indulge in all sorts of irregularities and dissipations. The crowding together of large numbers of people in badly ventilated quarters, favors the grave character and spread of this dread disease. It prevails very largely among the farmers and laboring classes of all the Western States and territories, and, when it enters a family, is very apt to attack all its members and persist indefinitely.

The *diagnosis* is usually very easy, although many cases of simple hyperæmia of the conjunctiva, or chronic cases of conjunctivitis, are treated severely and during long months for supposed granulations. The rough, rugose, and often "cockscorn" appearance of the everted lids, and of the retro-bulbar folds, is recognized at once. In more recent and milder cases, where the inflammatory deposits are not so large, the surface is less rough and characteristic, but still a very little experience will prevent its being mistaken. In the reflected folds, the deposits are often more sharply isolated, roundish, and somewhat elevated, in rows with the folds, semi-transparent, like frogs' eggs, and but slightly vascular. With more violent inflammation, swelling, and redness, their individual peculiarities cannot be recognized. Granulations are confined mainly to the tarsal and reflected parts of the conjunctiva, but sometimes extend to the sclerotic portion, and even to the cornea. In some instances the hypertrophied structures and infiltrations, although seemingly enormous, are superficial, and disappear with little or no trace of cicatricial lesion. In others, apparently not as bad, the new deposits are deep and destructive to the conjunctiva and tarsus, and are followed by serious lesions, distortions of the lids, and such impaired functions as to make the eyes almost useless and a life-long trouble. Deep or untimely cauterizations increase the danger of serious organic lesions, and their disastrous effects upon vision. There is always, preceding and accompanying granulations, inflammation with its symptoms, perverted and increased secretion, and more or less suffering and functional disturbance of vision. The droopy and sleepy appearance of the eyelids in these cases is pathognomonic, and yet the diagnosis must be made sure by direct objective inspection of the entire conjunctiva. To this end it is necessary to evert the lids. If the patient does not shrink back from the surgeon, and will look firmly to the floor, it will be easy to turn the upper lid in the way already described (page 590). The lower conjunctival folds are readily exposed by drawing the lower lid down while the patient turns the eye upwards. Inspection of the cornea is secured by sliding the lids apart while the patient turns the eye down, avoiding eversion.

Treatment of Granular Conjunctivitis.—In a long and large experience with this disease, I find the main difficulty to be in keeping the inflammatory element under safe control. The proneness to acute relapses, each setting the patient back and retarding recovery, must never be lost sight of. By wise circumspection these may be prevented or cut short, so that at last they will cease to occur, and the patient will get well. Just here lies the difficulty of treating these patients at long range. They need to be seen daily, and kept under the closest supervision, for weeks, and months, and even years. If, after proper treatment for a few days or weeks, they feel better, they insist upon going home, promising to "carry out the same treatment." If no better, or worse, they despair and change doctors. So they go the rounds, and come back, if at all, always worse. If frankly told at the start that the

treatment will be very long, and will require great watchfulness on both sides, they go to a more ignorant or less scrupulous surgeon, or to a brazen quack, who promises a certain and speedy cure. Such patients often try every silly thing they hear of, and express surprise, at last, that they do not get well! Peripatetic patients, with granular sore eyes, do not furnish good cases for a novice who wants to make a reputation. Great skill and eternal vigilance can alone guide to safe recovery. Ugly and fatal complications beset the long and crooked road that leads to relief, and few there be that walk wisely and patiently therein. The discriminating use of a few well-known remedies is the secret of successful treatment. The management of these cases must be very largely hygienic, as well as therapeutic. Cleanliness, great attention to the skin, diet, and clothing, exercise in the open air, rest of the eyes from close work, regular habits, temperance, and avoidance of all known causes of irritation, are conditions that must be enforced, otherwise no treatment can avail. Whatever conduces to the best health, is necessary to speedy recovery from any disease. If the farmer continues his laborious life, the student his studies, the good liver his fast ways, the intemperate his wild career, no science can save the eyes. The thorough obedience and coöperation of the patient must be secured. Except with free livers, restriction of diet and severe antiphlogistic treatment are not required, and are often injurious. Healthy, nutritious food at regular meals, orderly exercise in the open air, and a general course of tonics, are usually indicated.

The *local treatment* of granular lids is guided by two indications. The first, that of subduing the inflammatory reaction and keeping it within safe bounds. The second, that of producing temporary local stimulation, and thus promoting the slow and safe absorption of the morbid deposits. Their destruction by cauterization is not to be thought of. In the first stages of acute trachoma, and during the inflammatory relapses that are so troublesome and characteristic, local anodynes and soothing remedies alone are permissible. There is a natural tendency, under favorable surroundings, for the inflammation to subside after a few days or weeks. It should be allayed by mild treatment; not aggravated, prolonged, and rendered more dangerous to sight by violent applications. If tenderness to light, weeping, spasmodic closure of the lids, pain, and marked ciliary injection are present, the solution of atropia, four grains to the ounce, dropped in the eyes, from three to six times in twenty-four hours, is nearly always beneficial. The atropia instillation should be continued till these symptoms are overcome, abating its frequency as they subside. Cold-water bathing of the closed lids, at frequent intervals, in robust people, and during the acute stage, is grateful and useful.

The regular use of cold compresses, for a few hours at a time, helps to subdue the excessive local temperature. In the chronic stages, however, the acute relapses are often better controlled by warm fomentations that hasten the suppurative tendency, permitting astringents to be safely used. Moderate purgation once or twice a week, and opiates at night to ease pain and promote sleep, are valuable aids. Either from the start, or, better, after a few days, when the intolerance of light and weeping have given way to more or less mucous or muco-purulent secretion, a solution of boracic acid, five grains to the ounce, or of bichlorate of sodium of the same strength, may be dropped freely into the eyes three times a day. These solutions are somewhat astringent and scarcely at all irritating. To prevent painful adhesion of the lids at night, their edges may be greased with vaseline, fresh butter, or lard.

If keratitis sets in, as it is always prone to do, with abrasions of the epithelium, patches of infiltration, abscesses, and ulceration, the atropine should be applied oftener, and the other treatment kept up more rigidly. With this

complication, and sometimes without it, acute iritis is apt to occur, with its characteristic circumorbital pains. In that event, the mydriatics are all the more important. It is in view of this complication, which seems to be favored by the local use of eserine, that I am cautious about the use of the latter for the purpose of preventing the destruction of the cornea. The boracic acid, cold, compression with a bandage, opiates, quinia, and careful paracentesis, are the remedies in which I have most confidence. Still, I sometimes use a drop of the eserine solution directly to the ulcerated cornea, once in six or eight hours, keeping up the predominating influence of the atropine all the time.

This gentle and rational course, continued for a few days or weeks, is likely to subdue the inflammatory troubles, so that very careful local stimulation may be tried. The tolerance of light, absence of tears, and presence of more or less mucous or purulent secretion, with fading away of the sclerotic injection around the cornea, *especially above*, are favorable symptoms. In proportion to the amount of pus contained in the discharges, and the succulence of the conjunctiva, will be the preferability of nitrate of silver over other astringents or caustics. We begin with a five-grain solution, brushed quickly and lightly over the thoroughly everted lids with a camel's hair pencil, and quickly washed off with water, so that none of it touches the cornea. In twenty-four hours, if the reaction has been brief and the eyes seem better, the application may be repeated in the same manner. Little by little we feel our way, and determine the tolerance of the eyes. While a solution of this strength does well, its use may be continued. When it ceases to produce sufficient reaction, the proportion of the nitrate should be increased to ten grains. Stronger solutions than this are seldom required, and are not safe. Alternating the local remedies is nearly always found beneficial. Use one a few days or weeks, as long as it does good; then resort to another; and finally you may return to the first substance used, with advantage. The sulphate of copper in solution, or in smooth crystal, is a valuable remedy, and for long-continued use is preferable to the nitrate of silver, which is likely to discolor the conjunctiva. A five, ten, or even twenty-grain solution may be brushed on once a day, and then be well washed off, but most surgeons use the crystal, passed quickly over once or twice, and then freely washed away. When the retro-bulbar folds are thickened, the crystal can be passed back under the upper edge of the everted tarsus, so as to reach them. In many chronic cases, it is found that the neutral acetate of lead in saturated solution, and well washed away, acts very favorably and produces little reaction. It should never be used as a wash, dropped into the eyes, in such cases, for fear of precipitation in the cornea. Tannin, crystals of alum, and many other astringents have at different times been recommended, but if no one of the three remedies above described acts well, scarcely any other will. Of course the conditions that admit of safe local stimulation to encourage absorption, make the further use of atropine unnecessary. As it keeps the pupil dilated and paralyzes accommodation, thus causing great confusion of vision, and often alarm, it should only be used when decidedly indicated. In rare cases it produces atropinization and will not be tolerated at all. In these, hyoscyamine or duboisia must be substituted. Should an acute relapse occur during this course of judicious local treatment, as it is apt to do, drop the local irritants and return for a time to the soothing measures, and so with one or the other persevere to the end, which is nearly always far in the misty future.

In intractable cases of granular lids, with *pannus* covering and protecting the cornea, inoculation of gonorrhœal pus, first suggested by Friedrich Jaeger of Vienna, in 1812, has often been successfully practised. Brilliant results,

in the most hopeless cases, have been published from time to time, and adverse criticism has always come from those who have never tried the remedy. In 1855, Warlomont published a paper in high praise of this heroic treatment, in extreme cases, especially where the corneæ of both eyes were covered by pannus. In 1857 I myself published a paper on the subject, with the history of a very successful case. As the patient could see a little with one eye, I inoculated only the bad one, sealing up the other and keeping it free. After the subsidence of the violent reaction, I left the other eye open purposely, although only the upper half of the cornea was vascularized. On the third day this eye was attacked, but less severely, and the disease passed its climax spontaneously on the fourth day. From this time the lids of both eyes were everted, and brushed with a twenty-grain solution of nitrate of silver, once a day for eight days, when all suppuration had ceased. The granulations, which were enormous, completely disappeared; the sight of both eyes was so far restored as to enable the patient to read; and the last news I had from him, twelve months afterwards, he was following a threshing machine. He left the hospital seven weeks after the inoculation of the first eye, and three weeks after that of the second. I treated a number of cases by this means, and most of them with prompt success. They were all what might be called almost hopeless. Afterwards, I tried it as a last resource in the case of a little boy. Both of the eyes were lost by ulceration of the cornea. In this case I hardly had any hope of success, but the granulations were cured, and the patient was soon comfortable. In a second paper (October, 1857), I said: "The more advanced the pannus, by which I mean the more completely the cornea is covered with vessels and exudation, the less danger is there in the treatment. If the vasculo-membranous layer covers the entire cornea, and is so thick that the pupil can scarcely be seen, if at all, then there is very little risk in the procedure, and you are almost sure to restore the patient's sight, provided that the true substance of the cornea is not the seat of an incurable leucoma." If the pannus is only partial, some parts of the cornea remaining clear, or if though general it is so thin that clear spaces are left between the vessels, through which the pupil is distinctly visible, then there is more danger to be apprehended from the application of the pus. The thick, pathological coating formed by the pannus protects the tissue of the cornea from the violence of the inflammation produced by the matter, and wherever such a protection does not exist, softening and sloughing, or ulceration, are liable to occur.

But my impression is, from what I have observed, that undue importance has been attached to the contra-indication afforded by the partial transparency of the cornea, for in one of the eyes which I treated thus, there were several portions of the organ that were merely slightly hazy, and traversed only here and there by minute vessels. At several points the pupil could be distinctly seen, and yet I allowed the inflammation to go on uninfluenced by treatment, and the cornea did not suffer the slightest injury. The great danger from gonorrhœal conjunctivitis, when it attacks a previously healthy eye, is sloughing of the cornea from the violence of the inflammatory reaction, and more especially, perhaps, from the strangulation caused by the pressure of the chemosis. Now, where there is a panniform condition of the organ, aside from the mere protection afforded by the new formation, it is much less likely to slough, because it is nourished by the new vessels, and the circulation in it is not so easily cut off by the swelling. For the same reason, we seldom see sloughing of the cornea to a large extent after it has become vascularized in acute keratitis. In a case of granular lids, then, with even a moderate number of vessels scattered over the cornea, though the pupil is visible through nearly every part of it, I think that there is no very great

liability to ulceration, especially if the case be carefully watched and the inflammation promptly cut short on the first unfavorable symptom, as it almost certainly may be by the energetic application of nitrate of silver.

It is a rare thing for a well-informed ophthalmologist to lose an eye affected with gonorrhœal ophthalmia, if he sees it and treats it from the very commencement. Why, then, should he not be able to control the disease when artificially produced in an eye protected by a previous development of vessels? But experience alone can settle this question.

As to the *indications* for a resort to this treatment, they are few and simple. The first reason for inoculating a patient is that you have tried everything else, and have failed to cure him. After a fair experiment with the other agents recommended, if you fail to effect a cure, then you are certainly justifiable in essaying a measure that has rendered such signal services under similar circumstances. I say, after a *fair trial*, because I do not believe in waiting till the eyes are destroyed, or the corneæ so far disorganized that a cure is next to impossible. The sooner the remedy is applied, all things being favorable, the more likely we are to have a satisfactory issue. Patients may be cured in six weeks by inoculation, who would suffer for years, and perhaps never recover, under the ordinary treatment.

The same treatment, for the same reasons, has been more recently advocated by M. Ch. Abadie. His ability to control the violence of the reaction by brushing the everted lids twice a day with a ten-grain solution of nitrate of silver, prompts him to advise a more frequent resort to this therapeutic agent.

As an illustration of the thoroughness and promptness of this mode of treatment, as well as of its only danger, ulceration of the cornea, I give the following brief history:—

A very strumous lad, 17 years of age, came for treatment April 15, 1882. He was the victim of an acute attack of trachoma, of four weeks' duration. There was enormous thickening of the eyelids, lips, and nose. The granulations showed an exuberance such as I had seldom if ever seen. The right cornea was clear and intact, but the left showed some symptoms of superficial keratitis. He was treated for seven weeks, in the usual careful way, with some improvement. Early in June, he was taken with a violent purulent relapse which we could not certainly trace to inoculation. Taken at once to the Cincinnati Hospital, he was subjected to the most rigid treatment by Dr. S. C. Ayres. For two weeks, iced compresses were applied day and night. The lids were everted and brushed freely with a five-grain solution of nitrate of silver, twice a day, and were well washed off with water after each application. Both corneæ ulcerated in the centre, the ulceration on the left side ending in limited perforation with synechia anterior. On June 26, he went home much improved. In the beginning of September, he returned perfectly well. There were no traces of granulations, and but very small central opacities of the corneæ. On the 11th of December, he wrote that his eyes had slowly improved in sight, that he had had no back-set, and that he could read half an hour without fatigue; and he asked if he could safely go to school. This patient's general health was, and had ever been, wretched.

Quite recently, DeWecker has recommended the application of a watery solution of the seeds of the jequirity, as a safer substitute for inoculation. It is said to produce a milder form of suppuration from the conjunctiva, and to be equally efficient in its curative action. This remedy has long been in common use in Brazil in the treatment of "sore eyes."

In rare cases, after the lids have finally healed and have become as smooth as they ever can be, and when all distortions—trichiasis, phimosis, etc.—have been relieved by appropriate surgical measures, a chronic, vascular, relapsing keratitis may persist and require treatment. In these cases I have often succeeded well with finely powdered sulphate of copper. The upper lid is everted, once or twice a week, and a little of the powder applied

by means of a moistened probe, and let down immediately on the cornea. A drop of the perchloride of iron may be used in the same way, allowing it to run over the cornea. The reaction following its application is intense for a few hours, but the benefit is often very prompt and great. In the same cases a solution of eserine may be used once a day. It seems at times to bring about a marked improvement in the pannus. Another remedy, which is very soothing and safe for the patient in home use, is a salve of vaseline and boracic acid, fifteen grains to one-half ounce, to be put in the eyes twice a day. Mercurial salves of different kinds, used in the eyes for granulations and pannus, are of no value in most cases, and positively injurious in many.

With one other practical remark, I end what I have to say upon this important subject. In the advanced stages of granulations, when the morbid deposits are undergoing slow absorption, and cicatrization is setting in, we often find, when the upper lid is well everted, that the acino-tubular glands, along the back edge of the tarsus, are engorged by a sort of gelatinous substance which keeps up the irritation of the cornea and delays the cure. For many years I have been in the habit of pressing this rudely out with the two thumb nails, one slid behind and the other in front, and moved along the whole length of the tarsus. This being well done two or three times, at intervals of a day or two, very much expedites the usual local treatment. This procedure is painful, but it must be adopted firmly and without hesitation.

DISEASES OF THE CORNEA.

KERATITIS.—Inflammation of the cornea, in some form, is the starting point of most of its serious lesions. The clinical symptoms by which this process is diagnosed, are of easy recognition. Loss of the natural transparency is the first certain symptom. The degree of opacity may vary from the slightest haziness to the densest leucoma. With this physical change, is uniformly seen an alteration in the polish of the reflecting surface, giving it the appearance of ground glass, and causing images reflected from it to be blurred and indistinct. This depends on abrasions and irregularities of the corneal epithelium. With these objective alterations, there is associated the most characteristic subjective symptom, *photophobia*. The intolerance of light, in acute keratitis, is generally intense, particularly in scrofulous children. It is, however, by no means in proportion to the physical damage to the cornea and the degree of impairment of vision. The dread of light is often much more distressing than actual, severe pain. The latter may and often does occur, especially when there is infiltration and pressure on the nerve filaments of the cornea, or actual ulceration. In the latter case it is sharp and severe, like the thrust of a needle, but usually confined to the eyeball. With the photophobia is always very troublesome *epiphora*, and spasmodic closure of the lids. Of course the weeping is increased by exposure to light. When the eye is inspected, a more or less complete red zone of sclerotic injection will be seen around the cornea, fading out as it is followed toward the equator, which it does not reach. This group of symptoms is so characteristic that a mistake is scarcely possible. Blurring of vision, necessarily present, is not easily estimated, because the patient can open the eye but for a brief moment, and it instantly fills with tears. As the cornea performs a double function in the economy of vision, its lesions are all the more serious. With the sclera it constitutes the strong form-maintaining tunic, and, at the same time, it acts as a refracting medium. Faulty changes of curvature, giving rise to ill-defined images, and cloudiness leading to irregular and imperfect illumination, combine to make sight imperfect. Both changes are usual results of inflam-

mation. Irregular bulging of the cornea in chronic keratitis, and softening and yielding of limited, infiltrated or ulcerated portions in the acute forms of the disease, are by no means uncommon. Keratitis may be primary or secondary. The first class embraces all forms beginning in and spending their main force upon the cornea. The second includes all cases in which the cornea becomes involved, as a complication, in the course of some other disease of the eye. Primary keratitis may result from purely local causes, or may be due to a dyscrasia, such as scrofula or syphilis.

The *etiology* of this affection is often difficult of discovery, and sometimes only conjectural. Even when traceable to a constitutional affection, it is not easy to explain why it occurs in some cases and not in others, or in one eye and not in both. There are local determining causes that are, as yet, inscrutable. Even in traumatic keratitis, including that from chemical action, the seriousness of the reaction varies very greatly in different cases, without our being able in all instances to ascertain the reason. Excepting traumatic cases, and those in strumous and syphilitic subjects, primary keratitis is of rare occurrence. The most frequent exciting causes of keratitis are atmospheric changes and impurities. Secondary keratitis is of very frequent occurrence, in the course of acute conjunctivitis. In purulent conjunctivitis, keratitis, with its consequences, is the great and only danger. In the simple form of inflammation of the conjunctiva, the invasion of the cornea begins at the margin. At first there is perhaps simple abrasion of the epithelium, and superficial ulceration close to and parallel with the margin, assuming a crescentic shape. This may go deeper and lead to marginal perforation, but generally the part undergoes vascularization, and then gets well. In purulent conjunctivitis the cornea is apt to be invaded in its centre, where its nutrition is most precarious. The attack may begin in the form of a limited abscess, followed by open ulceration, or by direct ulcerative invasion. In either case it is likely to lead to perforation, and to very serious damage to vision.

There is a form of inflammation of the cornea, peculiarly destructive in its tendency, frequently of traumatic but often of spontaneous origin, that is usually called *hypopyium keratitis*. It might perhaps be better designated as *infectious*. It is nearly always seen in adults; often in stone masons, from contusions by fine pieces of stone; or in harvesters, from injuries by wheat beards. In these cases the injury seems slight and insignificant at first, and the severe reaction does not set in for two or three days. Those laboring under suppurative inflammation of the tear sac, are peculiarly liable to this trouble from slight wounds or abrasions of the cornea, or without any injury. The same source of local infection makes the extraction of cataract, in such persons, almost certainly destructive to the eye. This disease is characterized by rapid and limited infiltration, abscess, and ulceration, which is apt to spread both laterally and in depth, and which may lead to speedy perforation. A large portion or even the entire cornea may be thus destroyed in a few days. Very soon after the appearance of abscess and ulceration, an accumulation of pus is seen in the bottom of the anterior chamber, which increases, and may fill the entire chamber in a few days. The suffering is usually intense until perforation occurs, when it is apt to abate. In rare cases there is little pain or none at all. This disease always leads to permanent cicatricial opacity of the cornea and serious injury to sight, and in many cases to hopeless loss of vision. Its *etiology*, diagnostic symptoms, and treatment, are all somewhat peculiar.

Another variety, traceable often to hereditary syphilis, is called *parenchymatous keratitis*. It is seen nearly always in young persons of dwarfed appearance, and with the peculiar defect in the front teeth described by

Hutchinson.¹ Frequently there will be found nodes upon the shins, and other symptoms of tertiary syphilis. This disease is extremely persistent, leading to great cloudiness and vascularity of the cornea, and is often complicated by iritis and closure of the pupil. It nearly always attacks both eyes in succession. During its progress, or soon after its subsidence, a destructive inflammation of the cavity of the tympanum and labyrinth is liable to follow, terminating usually in total deafness.

Still another form of keratitis deserves special description. I mean the so-called *phlyctenular keratitis*, sometimes named *strumous*, because it nearly always attacks scrofulous, delicate, and precocious children. The pustule or pimple that gives it its peculiar name may be single or multiple, and situated anywhere on the cornea. It is usually small, and out of all proportion to the intense photophobia and suffering which attend it. The victims of this troublesome disease are likely to be afflicted by blepharitis ciliaris, phlyctenular conjunctivitis, otorrhœa, cutaneous eruptions about the face and scalp, enlargement of the lymphatic glands, and other scrofulous troubles. The seat of the phlyctenula makes all the difference possible in the symptoms. When on the conjunctiva of the sclerotic, it causes little suffering and soon gets well; but when seated on the cornea proper, extreme intolerance to light, spasm of the lids, and months of the most distressing suffering are likely to follow. The corneal phlyctenula sometimes ends in a small ulceration, and very rarely in perforation of the cornea with its consequences. The cornea is apt to become vascular, the little tuft of vessels running from the margin to the seat of the phlyctenula, and leaving after recovery often a corresponding band of opacity. In other cases there remains only a small speck of opacity, indicating the seat of the phlyctenula. The little sufferer is always worse in the morning, and better towards evening. Left to its instincts, the child will hide away in the darkest corner it can find, for weeks and for months; burying its face in the pillow, and holding its pale, bony fingers spasmodically on the eyes, fighting against the light with a deadly struggle. In warm weather the face will be soaked with sweat, the skin chafed and covered with eczematous patches, the eyelids fissured at the outer angles, and bleeding when pulled open, with scabs in and around the nose and behind the ears. This picture is graphic and pitiable, because true to nature. Photophobia, always a characteristic symptom of acute keratitis, is here most intense and persistent.

Variola is often followed by a severe and very troublesome form of keratitis. It comes on gradually, during desquamation, and results in great and permanent damage to sight. This form does not as often result in ulceration, perforation, and staphyloma of the cornea, as in dense opacity. It is always very obstinate, and requires an invigorating constitutional treatment. When *ulceration of the cornea*, under any circumstances, extends in depth, there is always serious danger of *perforation*. Mere perforation and loss of the aqueous humor, in itself, is not a dangerous termination. It is often to be desired and aided, rather than dreaded, as it is generally the turning point towards recovery. But if great care be not taken to avoid sudden perforation under pressure of the surgeon's fingers, or spasmodic contraction of the eyelids, a hernia of the iris will take place, with great increase in the immediate and remote danger to vision. As the cornea retains its natural curvature and position after loss of the aqueous, the lens is pushed forwards, carrying the iris before it, till its convex surface rests against the cornea and the anterior chamber is obliterated. If the perforation be large, sudden, and violent, not only extensive prolapsus of the iris may take place, but the capsule may

¹ See Vol. II., page 459, Figs. 339-344.

burst, and the lens be extruded from the eye, followed by vitreous. This, of course, is destructive to vision. A hernia of the iris, however recent and limited, cannot often be reduced, even by the most prompt and skilful management. If not reduced, permanent distortion of the pupil, more or less damage to sight, and indelible opacity of the cornea with synechia anterior; danger of partial staphyloma of the cornea, of chronic glaucoma, and of hydrophthalmic enlargement of the eye; repeated relapses of iritis and chorioiditis; and finally danger to the other eye from sympathetic ophthalmia, will follow. Hence the vast importance of preventing prolapsus and saving the eye with the least possible damage to the sight. If the perforation is limited and central, the iris is much less likely to prolapse than when the ulcer is seated at or near the periphery.

There is likewise a form of keratitis called *neuro-paralytic*, due to paralysis of the sensory branches of the fifth pair of nerves. In this case the cornea becomes insensible to the touch, and does not feel the presence of foreign particles. Its surface becomes dry from long and unconscious exposure to the air; inflammation, sloughing, and ulceration take place; and the eye is rapidly destroyed. This disease is not as much, if at all, due to the trophic influence of the corneal nerves as to the cornea's unfelt exposure. In cases where the corneal sensibility is not entirely destroyed, the pain in this disease may be intense:—

On April 9, 1878, I was consulted by a lady, 54 years old, laboring under this disease of the cornea. When 19 years old she had had a "wen" removed from the left brow. It seems that the surgeon in stitching the skin injured the supra-orbital nerve, or one of its important branches. She felt it "all over her" at the instant. Total loss of feeling followed in the left forehead and eye. This lasted perhaps ten years, when partial sensibility returned and thus remained. There is now a linear cicatrix beginning 3 cm. from the median line, and 1 cm. above the brow, and running parallel with it. At the time of her visit she was suffering with severe pain in and around the eye, and a very distressing "feeling of numbness." Tension little, if at all, altered. She declared that the sight was abolished, but could not bear the use of the ophthalmoscope. There was a small ulcer a little outwards from the centre of the cornea, with some filamentous adhesions of the margins of the pupil to the lens capsule. The whole left side of the face and eye showed partial anæsthesia. I treated her with occasional use of atropia, compress and bandage, and repeated paracenteses of the cornea, making thirty in all, at intervals of one or two days. She recovered at last, with fair vision, and has continued well; but the imperfect feeling remains as before the attack of keratitis. A small crescentic opacity of the cornea, opposite the outer edge of the pupil, is all that remains visible now.

The destructive inflammation of the cornea that comes on in low cases of typhoid fever, with comatose symptoms, and in meningitis and other exhausting diseases which are nearing their fatal termination, is due to the same cause, and may be often prevented by keeping the eyes closed and moist. The same precautions should be taken to protect the eyes in their extreme protrusion in Basedow's disease, where sloughing of the cornea is the sad result in so many cases. Here it is due simply to inability to close the lids and protect the eye.

I have already described the corneal troubles which are due to conjunctivitis and to granular lids, and the lesions which so often follow.

Treatment of Keratitis.—First, let us consider those secondary forms that come on in the course of acute attacks of conjunctivitis. In severe cases of catarrhal conjunctivitis, with photophobia, weeping, ciliary injection, and more or less severe pain, this is the complication to be dreaded and guarded against. Sulphate of atropia, four grains to the ounce, should be freely dropped into the eye from three to six times a day. In robust subjects, cold

compresses, often changed, and persevered in during the acute stage, are nearly always beneficial. Moderate purgation in the beginning, and full doses of anodynes at night, will aid greatly in controlling the disease. No astringent or irritating applications to the eyes should be allowed, as long as the intolerance of light, weeping, and ciliary injection, are at all pronounced. They always do harm, and greatly increase the danger to the integrity of the cornea. If the patient is feeble and anæmic, good nutritious diet and tonics are the safest constitutional remedies. In such persons warm applications are better borne, and dry absorbent cotton and the bandage, with occasional cleansing of the eyes, will be most grateful and satisfactory. When the local, anodyne, and other cooling and soothing treatment has been continued some days or weeks, till the dread of light, weeping, spasm of the lids, and all injection of the sclera, especially above the cornea, have passed away, then a change to prudent stimulation may be thought of. The patient now opens the eye in the light. It weeps little if any, and there is a more abundant secretion of mucus or muco-pus. Biborate of sodium five grains to the ounce, alum two grains, sulphate of zinc or sulphate of copper one-half grain, dropped into the eyes freely twice a day, will be well borne and will do good. A solution of boracic acid ten grains to the ounce, being unirritating, may be used earlier, or even from the start.

Should a relapse of keratitis occur, the employment of these astringents must be suspended, and the use of atropine, and other soothing remedies, must be recommenced. Should purulent infiltration and ulceration ensue, the atropine and boracic acid must be used more frequently. If ulceration take place, *near the margin of the cornea*, with threatened perforation, it is wise to omit the mydriatic in favor of eserine, to contract the pupil, make the iris rigid, and prevent extensive prolapsus. On the contrary, where the seat of threatened perforation is central, the pupil should be kept fully dilated, as the best safeguard against prolapsus. In case the ulcerative process is attended by great pain, with or without hypopium, a careful paracentesis of the cornea should be tried, in preference through the thinned bottom of the ulcer, and the aqueous humor carefully, but completely, evacuated. For fancied, theoretical reasons, some would advise eserine exclusively, in all cases of ulceration and infiltration of the cornea; but it is objectionable, because it greatly increases the danger of iritis and its consequences, always present in such emergencies. If there is increased intra-ocular tension, hypopium, and great suffering, nothing is so prompt and sure as the free use of atropine and paracentesis. If the edges of the ulcer are infiltrated and undermined, showing rapid lateral spreading, these same expedients may be followed by cauterization of the sloughing edges with carbolic acid. A small probe or hardwood toothpick, dipped in the acid, should be rapidly swept around under the necrotic tissues, rendering them white, acting as a prompt antiseptic, and arresting the destructive process. For many years I have been using the acid in this way, with increasing satisfaction. If anything can save an eye from total destruction in hypopium or infectious keratitis, it is the use of this remedy, repeated once or twice a day, following Saemisch's free corneal incision, which is made, in such cases, with a Graefe's cataract knife. The patient being under ether, and the eye fixed, the knife is passed through the cornea, near one edge of the ulcer, carefully pushing the point behind the ulcerated spot and making the counter-puncture, the edge presenting forwards, on the other side. Then by pushing the knife slowly and gently forward, the width of the ulcerated portion is split. The aqueous escapes with the shreds of lymph from the chamber, and complete relief of tension follows. If tough shreds hang in the incision, they may be drawn out with small iris forceps. Once a day afterwards, the lips of the cut are opened

carefully with a probe or the probe-end of a Weber's stricture knife, and any gathering aqueous is allowed to escape. The eye should then be bandaged with carbolized or borated cotton, and opened once or twice a day for inspection, for the carbolic application if needed, and for the tapping of the chamber. Carbolic acid used in the same way, before or after simple paracentesis, repeated cleansing, continued use of cold water, atropine and boracic acid solutions, with free incision of the outer commissure to relieve pressure upon the ball, combined with the proper treatment of the purulent conjunctivitis, are the best means of saving the cornea in that dreadful disease.

In the management of phlyctenular keratitis, attacking as it always does delicate, scrofulous children, great importance attaches to the hygienic conditions of the patient. The child must have good nutritious food at regular intervals, and no cramming with trash between meals. Its body must be bathed once a day with tepid water, and the skin thoroughly rubbed. It must be dragged from its burrow in the dark, and carried forcibly out in the fresh air, for an hour or two twice a day. It must not be allowed to bury its face and heat up its eyes, and the room is to be only moderately darkened and is to be kept well ventilated. It will add greatly to the child's comfort and relieve its photophobia, to bathe its face thoroughly several times a day with very cold water. Immersing the face in a basin of iced water several times in succession, has a wonderful influence in controlling the spasm of the lids and enabling the child to open its eyes in the light. Any eczematous patches of the lids and nose, and fissures at the outer commissure of the lids, must be cleansed with soap and water, dried thoroughly, and freely brushed with a twenty-grain solution of nitrate of silver once a day till cured. Inwardly, quinia, two grains three times a day, for a child five years old, has a marked effect in controlling the photophobia. It may be kept up several weeks, if necessary, and followed by a long course of small doses of iron, the syrup of the iodide being one of the best preparations. Locally, atropine may be freely used from the start, and kept up for several weeks, or till the child opens its eyes freely in the light. Combined with it, or separately, a solution of boracic acid is beneficial. No astringents of any kind must be used in the acute stages. In a child from five to ten years old, a solution of two grains of sulphate atropia in an ounce of water, must be freely dropped into the eye three or four times a day, taking great pains to forcibly open the lids and get it in thoroughly. Care must be taken in the struggle to do this, not to drop or let the wash run into the mouth. The best way is to lay the child backwards, across the nurse's lap, and to take its head between the surgeon's knees, face upwards. Then pull the lids well open, and apply the wash freely.

When the photophobia is relieved, a weaker solution may be used, and less often, till it is finally omitted. The greater the intolerance of light, the more urgent the use of atropia, and the less danger of any poisonous effects. Where the phlyctenular process persists, and perhaps keeps pushing forward in the form of a band, more towards the centre of the cornea, in spite of this treatment, I again resort to the local use of carbolic acid. The offending patch or band in the cornea, is usually seen covered with a dirty-grayish, necrotic tissue. Holding the child's head firmly between the knees, as before, and separating the lids well, even using an elevator so as to expose the cornea fully, the spud may be used to freely scrape off this sloughing epithelial tissue, and even to bore out the phlyctenula. Then with the same spud, or a small probe, the acid is applied, limiting this carefully to the necrotic portion, turning it whitish, and then washing it with a few drops of cold water. This is done once a day, continuing the local use of the atropine. It is wonderful how quickly the extreme symptoms in such cases, may be thus overcome. The necrotic tissue, with too little life to live and too much to die, in the troublesome keratitis

following smallpox, may be treated in the same way, with warm fomentations in addition, atropine, and tonics, with good diet. In phlyctenular keratitis, after the intolerance of light is overcome and all the acute symptoms have abated, the atropine should be omitted, and gentle, local stimulation employed. By general consent, the local use of pure, finely powdered calomel, dusted on the cornea once a day, is the best means of clearing off the remaining opacities. If the child is not timid, the powder may be driven suddenly on to the cornea by tapping the brush. In case it is refractory, its head may be held between the knees, as in using the eye-water. If this treatment acts well, it should be continued for weeks and months, till all corneal traces have cleared away. Weak astringents, excepting the acetate of lead, may be used for the same purpose, dropped into the eye once a day. Of course the iron and other tonics, cod-liver oil, malt, etc., with good diet, should be continued for months after the child is seemingly well. Otherwise the disease will recur. For convenient local use, the calomel may be applied in the form of a salve with vaseline, one grain to each drachm.

Syphilitic parenchymatous keratitis must be treated constitutionally as well as locally. The dwarfed figure, old and leathery face, characteristic teeth, perhaps nodes on the shins, and rheumatism of the knee-joints, can hardly be mistaken. And yet the worst forms of scrofula are so allied to syphilis that their differential diagnosis is by no means easy. It seems indeed that the two diatheses are often combined, and when syphilis and scrofula are married the offspring cannot be happy! A patient resort to tonics, good food, and careful hygiene, is necessary in all such cases. If the symptoms are such as to make it certain, or even probable, that tertiary syphilis is the fundamental malady, the careful use of mercurial inunctions and free administration of iodide of potassium must be added, and long and carefully persisted in, if a cure is expected. As iritis is often associated with this disease of the cornea, the free use of atropia, three or four times a day, is indispensable. Local stimulants in any form only aggravate the disease and intensify the danger. Warm fomentations, or poultices often renewed, and kept up for six or eight hours a day, are of great value. It is often a source of surprise, to see how well such cases generally recover sight, even under the most hopeless appearances. But the treatment will be long in every case, with occasional relapses. Rarely, undue hardness of the globe, pain, increased failure of vision, and other evidences of secondary glaucoma, will show themselves. In that case, notwithstanding the presence of iritis, the atropia must be omitted. Warm applications, long continued, and eserine two or three times a day, must now be the main reliance.

Should the excessive intra-ocular tension not yield in a few days to the eserine, an iridectomy must be tried. In the case of a girl fourteen years old, with this form of keratitis in both eyes, glaucomatous hardness was detected in one eye, and iridectomy proposed for the next day. In the mean time, a solution of two grains of eserine in an ounce of water was instilled every six hours. When the time came, the hardness was reduced and no operation was necessary. In some very malignant cases of this affection, the corneal infiltration leads to a sort of sclerosis and tendinous opacity of the entire cornea. In an instance of this sort, recently, in a little girl of eight years, with increased tension and pupillary membranes in both eyes, I practised a double iridectomy, as a last resort. Some months after, the eyes began to improve slowly, and the girl now has useful and improving vision.

Following ulcerative destruction of the cornea, two changes may occur: one, *flattening*, with more or less diminution of the globe in size; the other *protrusion* with enlargement, called *staphyloma*. If most of the cornea has been destroyed, with sudden perforation, and loss of the lens and part of the

vitreous, the former is likely to be the result. Where the lens is not extruded, the cicatricial tissue, composed of the blended remains of the cornea and iris, is likely to yield slowly to the pressure from within, and show an unsightly prominence. The deformity and inconvenience of a corneal staphyloma vary much in different cases. If neither be very great, the patient may be let alone, and watched. If the deformity be unsightly, and especially if the protrusion be constantly inflamed and painful, surgical interference is demanded. Should the whole globe be enlarged and seriously altered, the eye being a constant source of pain and danger, enucleation will be safest. But if the changes are confined to the corneal region, the back portion of the globe being natural in appearance and size, the staphylomatous portion may be removed. Thus the eye will be reduced in size, and the patient enabled to wear an artificial eye. I prefer a reduced stump like this, to the small movable button only, that remains after enucleation. But in either case, an eye can be worn with comfort and great benefit to the personal appearance. The easiest and best operation in such a case, is simple ablation. The patient lies on his back, and does not often require ether. The lids are separated by the fingers of an assistant, or by the stop-speculum, the eye is fixed by stout forceps, and the desired portion removed by a Beer's cataract knife. The tumor being transfixd from temple towards nose, with the edge of the knife held upward, rapid movements are made to finish a regular flap above. Then, seizing this flap quickly with toothed forceps, the knife is turned, and the removal finished below. Of course the lens escapes, and a gush of vitreous follows, before the knife is reversed. But the section must be completed quickly, the lids instantly closed, and a cold compress applied by a rather firm bandage. Otherwise hemorrhage may take place from the bottom of the eye, pushing out the remains of the vitreous, and may be followed by suppurative elimination and extreme atrophy of the stump. Several ingenious methods have been practised, in which the conjunctiva is stitched to close up the opened cavity. But this causes delay, and does not leave as regular a stump for the glass eye as a well executed, simple ablation. The closed lids, with pressure kept up for a few days, secures a good result. In old persons, with appearances that indicate danger of hemorrhage, enucleation is safer, and the result more prompt. (Plate XXVII., Fig. 5, represents a well-marked case of the form of staphyloma known as *buphthalmus*.)

A word as to *prothesis*. The patient nearly always wants a larger eye than he ought to wear. After enucleation of a much and long enlarged eye, there is an immense cavity, and the wearer thinks that this ought to be filled out even with the other eye. It cannot be, without glassy staring, and immobility and discomfort. The artificial eye should always be smaller than the other, allowing easy closure of the lids over it. It is seldom that the same eye can be worn more than twelve or eighteen months with comfort and safety. If corroded on its surface or edges, irritation, slow adhesions of the lids to the stump, and contraction of the space will follow, till no eye at all can be borne. An atrophied eye, with the clear cornea preserved, will very seldom tolerate an artificial substitute, and wearing it may give rise to sympathetic ophthalmia. Dense leucoma of the cornea, in an eye of natural size and free from irritation or increased tension, may be greatly improved in appearance by *tattooing*. This is done with pure India ink, and generally requires to be repeated two or three times, to secure sufficient staining. The patient lies on his back, with his eyelids well propped open, and the fluid, brushed on the part to be stained, is pricked in very thoroughly with the tattooing needles. The ink is applied repeatedly, and the needles used, till the coloring is satisfactory. When done, the cornea is left exposed for some minutes till it dries.

Little irritation follows, and the cosmetic process may be repeated, at intervals, till the end is gained. If not a source of pain and danger to the other eye, and presentable in looks—or if it can be made so—I much prefer to preserve the natural eye. Artificial eyes are an endless source of trouble and expense, and few persons are so prudent as to be able to wear them at all, for many years.

DISEASES OF THE IRIS.

MALFORMATIONS OF THE IRIS.—Among malformations of this part may be especially mentioned the affection known as *coloboma iridis*, or congenital fissure of the iris, and that known as *multiple pupil*, of which a remarkable example, involving both eyes, is illustrated in Plate XXVII., Figs. 3 and 4.

IRITIS.—Remembering the delicacy and wonderful activity of the iris, we are not surprised to find it the seat of frequent inflammation. Iritis may run an acute course, or may appear in a slow and insidious form.

Symptoms.—These, in most cases, are so sharp-cut and characteristic, that a false diagnosis is inexcusable. And yet how often is this disease pronounced “sore eyes,” and treated with nitrate of silver, till hopeless closure of the pupil takes place! While iritis yields to timely and intelligent treatment, with great certainty, nothing can be more fatal than such a mistake of diagnosis. Severe and somewhat paroxysmal pains in the eye and face, too, are attributed to simple neuralgia, with serious delay in the recognition of the true malady. Hence the vital importance of a speedy and correct diagnosis. The *objective* symptoms are discoloration, loss of the natural brilliancy of the iris, as well as of its fibrous appearance, sluggishness of the pupil, and finally adhesions to the capsule of the lens, synechia posterior. The changed color, depending much upon the original color of the iris, is explained by the increased amount of blood in its texture, and the extravasated elements. When but one eye is affected, the color contrast and difference in the activity of the pupils will be striking. Sometimes the occurrence of inflammatory nodules, near the pupillary margin or elsewhere, will attract attention. There is no one symptom, or group of symptoms, that is so pathognomonic of syphilitic iritis as these gummy formations. Hypopium is not very infrequent, but is oftener detected in ulcerations of the cornea, particularly when deep and threatening perforation. A pinkish zone of injection around the cornea, fading in intensity towards the equator of the eye, is another constant symptom of acute iritis. Now and then inflammatory chemosis, and extravasations of blood over the sclerotic conjunctiva, are seen, and indicate an intense form with probable panophthalmitis. There is always some impairment of vision, and often a very serious one, capable of being demonstrated objectively by the type tests. Blurring of sight is due to cloudiness of the aqueous humor, deposits in the pupil, and sometimes to turbidness of the vitreous, due to complicating choroiditis. Indeed, it often happens, that optic neuritis or neuro-retinitis, develops with an iritis, but is overlooked.

Subjectively, the patient complains of intense pain in and around the eye, usually aggravated at night, or by lying down. These severe, circumorbital pains are characteristic. Sometimes the pain is confined to the eye; at other times it is exclusively in the bones around; but usually it is in both. Photophobia and weeping are not strongly marked in this disease, as they are in keratitis. The sluggishness of the pupil, in response to varying degrees of light, may range from complete immobility to but slightly diminished motion. This may be due to spasmodic contraction of the irritated sphincter, or to

plastic exudation, or to both. It is not easy to tell, by simple inspection, whether adhesions of the iris to the lens capsule are present, and to what extent. Hence the value of atropine, in the diagnosis. If no synechia exists, the pupil will dilate circularly, and eventually largely. But if bound down, the points of adhesion will remain fixed, while the free portions dilate. This gives the pupil a strikingly irregular form, and makes their presence positive. By the use of atropine and oblique illumination, the adhesions can be seen with great satisfaction.

Iritis is practically divided into plastic, suppurative, and serous. These forms sometimes exist together. The *plastic* is distinguished by a free effusion of lymph, with prompt and firm adhesions to the capsule, and false membrane in the pupil; the *suppurative* by hypopium; the *serous* by less marked ciliary injection, less pain usually, and a more insidious course. Likewise, with turbidness of the aqueous, and dimmed vision, there are seen groups of minute, dirty points of precipitates on the membrane of Descemet. These are best seen by oblique illumination, and through a magnifying lens. In serous iritis, there is often an associated disease of the ciliary body and choroid, with increased tension of the globe. This glaucomatous hardness is a very serious complication, and the surgeon should never fail to search for it every day. Its possible development should make us cautious in the use of atropine, which increases the tension. Its actual presence forbids atropine altogether, and calls for eserine, which diminishes intra-ocular pressure. When this complication arises in serous iritis, the pupil becomes dilated and sluggish, but even then slight adhesions with the capsule may form. There are likely to be inflammatory deposits in the extreme rim of the anterior chamber, and peripheral adhesions between the iris and cornea, with obliteration of Fontana's spaces. This is said to arrest the filtration of fluids from the eye, and to give rise to increased tension.

In sympathetic ophthalmia, serous iritis is much less dangerous and more controllable than the plastic variety, which nearly always leads to blindness. The so-called condylomatous variety (gummatous) is nearly always syphilitic. There may be but one nodule, or many. If numerous and large, they rest against the cornea, and completely fill the anterior chamber, as I have seen in a few cases. They are always permanently glued to the lens, and the iris-tissue afterwards undergoes atrophy to a high degree. Sometimes hypopium is associated with them, and may rarely be the result of an abscess of the iris bursting into the aqueous chamber.

In the *etiology* of iritis, syphilis is by far the most prolific cause. After this come the rheumatic diathesis and scrofula. Of course an injury may occur and produce its effect in any constitution. Iritis from injury is apt to be mild, except when irritated by a traumatic cataract, or by a foreign body in the eye. As a syphilitic disease, iritis usually is one of the so-called secondary manifestations. It may be present with ulcerated throat, eruptions on the skin, and falling away of the hair; but not infrequently it precedes all of these lesions, while in other cases it follows them at some distance. The presence of iritis in any given case does not prove the existence of syphilis, but should always awaken thoughtful inquiry.

The diagnosis settled, and the etiology cleared up as well as possible, we inquire, what is the *prognosis* of iritis when left to itself? Its tendency is to recovery, but with permanent adhesions and some impairment of sight; besides, any remaining synechia increases the tendency to repeated relapses, and to final destruction of vision, giving rise at a later period to choroiditis and to glaucoma.

Treatment of Iritis.—This divides itself into local and constitutional. The main indication, of course, is to cut the disease short, if possible, and save the

eye from permanent lesions and their consequences, immediate and remote. The chief object in the use of *local remedies* is to relieve suffering and dilate the pupil fully, so as to prevent adhesions and false membranes. The mydriatics must be used promptly and heroically, from beginning to end of the treatment. If the pupil can be dilated, and kept so, thus preventing adhesions—or, in case they have already formed, if they can be detached and kept from reforming—a great point is gained for the integrity of the eye. The cheapest and best substance of this class is the sulphate of atropia. It may be used for adults in a four-grain solution, dropped freely into the eye every three or four hours, or every hour at the start, till the pupil is freely dilated. The only danger from its free use is constitutional disturbance. If prevented from entering the puncta and running down the throat, there is little risk. This is done by drawing the lower lid a little from the eye, and holding it a few minutes after each application. A cloth over the end of the finger is then pressed into the corner to remove what remains of the atropia solution. The frequency of application should depend on the pain and the resistance of the pupil. As soon as the latter yields largely, the use of the atropia may be less frequent, but enough to keep up full dilatation.

The pain is much relieved, and the relaxing influence of the atropine hastened, by leeching. Four leeches may be applied to the temple, or side of the nose, at once. Then, as fast as one is filled and falls away, another may be applied, till six, eight, or ten have bitten. The bleeding is encouraged by warm fomentations. The leech should never be allowed to bite on the loose skin of the lids. Of course the eyeball must be guarded with great care. I prefer the natural leech to the artificial, or to the ordinary wet cupping. Still, Heurteloup's artificial leech, applied to the temple, does well.¹ Local depletion is not generally necessary, but expedites the cure, when used. Cold water applications are not beneficial. Warm fomentations, or the persistent use of warm poultices, in the obstinate cases, particularly if there is a glaucomatous tendency, are often of great benefit. Of course, purgatives in the beginning, and at times afterwards, with free anodynes at night to allay pain and promote sleep, are valuable antiphlogistics. In cases of patients harassed by great pain, with resistance of the pupil to the action of leeches and atropine, I have often given immediate relief by a paracentesis. If preferred, a subcutaneous injection of morphia may serve the same purpose, but it has not as much control over the progress of the disease. I often anticipate the use of leeches by the paracentesis. In the serous variety, atropine must be used less freely, and with more watchfulness, omitting it at once, and resorting to eserine, if increased tension is discovered. In such emergencies, the protracted use of warm poultices, often renewed, does great good. If the glaucoma resists all these, a paracentesis should be tried, and then, if need be, an iridectomy. Do not let this fatal condition run on very long. If the atropine disagrees or proves insufficient, a four-grain solution of duboisia is still more powerful, but more care is needed to watch against its general effects.

Constitutional treatment is directed especially to the diathesis found to exist. In the rheumatic, salicylate of sodium, the subcutaneous use of pilocarpine, and other numerous and vaunted remedies for rheumatism may be tried. Great attention to the stomach, kidneys, and cutaneous function, with careful avoidance of exposure to cold, is required. If the syphilitic virus is present, mercury, by inunctions, inwardly, or by baths, is indispensable. Following this, or from the start, if the patient is deteriorated in blood and strength, the iodide of potassium is an invaluable remedy. Some form of general

¹ See Vol. I. page 513, Fig. 81.

treatment should be kept up for months, to prevent relapses, and the atropine ought to be continued, once or twice a day, for several weeks after all local symptoms of inflammation have ceased.

If extensive synechia results, and relapses follow, an iridectomy will, probably, rescue the eye. Should the pupil be closed by a dense false membrane, and all communication between the chambers cut off, this is to be done at once. Still greater urgency is demanded if the periphery of the iris has begun to bulge forwards, the pupillary area being drawn back. In syphilitic iritis, the constitutional symptoms, and the local inflammation, should be well controlled before doing an iridectomy, as otherwise plastic formations will again close the pupil. In chronic forms of iritis, with acute relapses, an iridectomy is often a valuable antiphlogistic, and the only means of arresting the disease. But there is room for great discretion in deciding that such an emergency exists as requires iridectomy, and great skill is needed for the execution of so important an operation. People are always ready to attribute the most absurd and remote consequences to the direct action of a surgical operation, if any has ever been performed. Little need be added on the method of this operation, to what will be found under cataract and glaucoma. I much prefer the Graefe to the spear knife, especially with a shallow anterior chamber. When the iris is free from all adhesions, and its tissue not rotten and friable from disease, the operation, after the incision, is very easy. When adhesions are confined to the pupil, the rest of the iris being free, no difficulty is usually experienced in seizing and drawing it out. But the entire agglutination of the posterior surface of the iris to the lens capsule, makes a satisfactory iridectomy almost impossible. In such extreme cases the lens will need to be extracted, and afterwards the tough membrane, composed of iris, inflammatory deposits, and lens capsule, should be freely incised with Wecker's *pince-ciseaux*.¹ Hopeless as seem some of these cases, they should not be given up till such thorough operations have been faithfully tried. Success sometimes crowns a desperate effort.

TUMORS OF THE IRIS.—Tumors, benignant as well as malignant, sometimes develop in the iris. The former, when not too large, may be removed with the portion of iris in which they grow. The latter, of course, demand an enucleation of the eye, as the only hope for life. Among the former are rare dermoid growths, that take their origin from rudiments of skin, driven in and lodged on the iris by injuries. A more frequent development in the iris, always following an injury, is a cyst. Plate XXVII., Fig. 2, represents such a growth. The eye had been injured by a small shot, which lodged in the iris. After long years, the cyst developed and grew to a degree that destroyed the sight, and caused great suffering. I enucleated the eye, and in making sections for microscopic examinations, the shot was cut through. The entire extent of the cyst wall is seen in the illustration. In another case, in a boy of nine years, the cornea had been injured by the sharp corner of a piece of slate. A cyst afterwards grew from the iris, and attained a large size. I removed it with the iris from which it grew, but in a few months another cyst showed itself. This was also extracted in the same way, with permanent relief, and preservation of some sight. In a third case, I extracted a cyst that I had mistaken for a lens in its capsule, luxated into the anterior chamber. I made quite a free incision in the cornea, and, finding my mistake, removed the cyst and iris as usually advised. The patient recovered promptly. Since then the cyst has been partially reproduced, but seems to have been obliterated by an attack of inflammation, and now appears cured, with some

¹ See Fig. 934.

vision. Had I made a critical examination of this patient's eye, the mistake could have been avoided; but the operation would have been essentially the same, and with the same result. The eye was inflamed and painful, and the history and strong resemblance to a luxated lens led me to operate at once.

CATARACT.

The most striking physical property of the refracting media of the eye, is their great clearness. Without this, neither the cornea, the crystalline lens, nor the vitreous could act as image-producing structures. The absence of bloodvessels in them, and the transparency of their elementary textures, secure their perfect functional action. And yet they are vital, animal membranes, moulded and arranged as a system of lenses. Nutritive changes are constantly going on in them, as in other parts of the body, but their nutrition is precarious in proportion to the distance of their source of supplies, and the difficulties of transportation. The wonder is that their lesions are so rare. The lenticular system is composed of the lens proper, the inclosing capsule, and the suspensory ligament by which it is held in place. The transparent capsule closely embraces the lens, and is united with it by means of a layer of intracapsular cells, through which the nutritive changes are effected by a system of endosmosis and exosmosis. Of course, the influx and efflux of the nutritive fluids must be through the capsule. The supplies are second-hand, from the vitreous and the aqueous humors. Hence morbid changes in the chemical composition of either or both these humors may affect the nutrition of the lens, and produce cataract. Their supplies also come from without, the aqueous probably being secreted by the bloodvessels of the ciliary processes, and the vitreous mainly from the choroidal circulation. Hence disturbances in the free circuit of fluids through the capillaries of these tissues may indirectly affect the lens and cause cataract. Then again, as all the tissues are fed from the blood, an abnormal change in the healthy constituents of this pabulum may lead to disease in any organ, especially in the transparent and bloodless structures, like the lens. Finally, the daily dying of the living body, that begins *in utero* and ends in death, results from the increasing stagnation of the vital currents, with the progress of years.

In the crystalline lens, the gradual changes of consistency, from hardening and drying of its textures, are indicated by the progressive failure of the accommodation with increasing years. This prepares the way for senile cataract. In childhood, the lens is soft and elastic, yielding in form to the delicate action of the ciliary muscle in focusing for very near objects; but this elasticity is slowly lost, till, at sixty or sixty-five years of age, no power of accommodation is left. Presbyopia then is due to physical changes in the lens, and comes to all as age advances. But its inconveniences differ according to the refraction of the eye.

Suppose the subject is *myopic* in a rather high degree, say one-eighth, which means that his farthest point of distinct vision is eight inches from the eye. In boyhood, by voluntary action of the ciliary muscle, he can read, and prefers to read, at three or four inches, his nearest point of easy accommodation. As he grows older and the lens hardens, he prefers to read a little farther away. The near point thus gradually recedes towards his far point, which it reaches when he is fifty or sixty years of age. Then he reads at his far point (which is not *far*), eight inches, and reads well without the aid of glasses. His range or power of accommodation is gone, and his myopia remaining the same, all these years, with the same imperfect sight for distance, the failure of focusing for near objects is not felt. The patient even imagines that his

near-sightedness has improved with years, because he reads with the book farther away now than when young. Actually it has not, and he now needs a negative lens No. 8, for perfect distant sight, as always before.

Suppose the refraction of the eye is *emmetropic*. Then the patient has a range of accommodation, say from three inches to an infinite distance, when young. As years flow on, his near point goes away towards the far point, and at forty or forty-five has reached ten inches, when he begins to feel the need of glasses to read. When all focusing power is gone, the near point has gone out to an infinite distance, the far point of an *emmetropic* eye. Such a patient must have magnifying glasses to read, but sees perfectly in the distance without any aids.

Again, let us suppose that the refraction is *hyperopic*. In *emmetropes* the ciliary muscle is at complete rest in all but close work. In *hyperopes* it is always on a strain, except when the eyes are shut, as in sleep. Now with years, the same hardening process goes on in the lens, and the near point recedes. Such persons often need convex glasses to read with, even when young, because the strain on the accommodation is excessive and fatiguing. *Presbyopia* tells on them much earlier than on *emmetropes*, and when all accommodation is gone at from forty-five to sixty years of age, the sight fails for distant as well as for close objects, and they see badly far off without glasses, and still worse near at hand. Such an unfortunate now needs two pairs of magnifiers, a weaker for distance, and a stronger for reading. These are the three ordinary conditions of refraction, two of them anomalous, and one perfect. Only one other anomaly exists, and that is *astigmatism* in its two forms, *hyperopic* and *myopic*. Correctible *astigmatism* is due mainly to irregularities of curvature in the cornea, and hence may be left out in this hasty summary of inconveniences from hardening of the lens. These practical observations seem necessary to a clear understanding of the pathology of cataract.

While cataract is seen at all ages, and may even be congenital, it is much most frequent in advanced life. The natural, nutritive change that takes place in the lens of an elderly person, supplies a good soil for senile cataract. In old people the nucleus of the lens is large, hard, dry, and of an amber color, even when clear. Its wear and repair have in a good measure ceased, and the nutritive activity of even the cortical lens substance is very sluggish. Hence, any of the causes that bear heavily on nutrition, may determine senile cataract. While any one, without regard to parentage, may become a victim of cataract, still there is a strong hereditary predisposition to it in certain families, which shows itself in the young as well as in the old. The members are attacked, usually, at about the same age. The *etiology* of cataract is often inscrutable. The hardening and drying nucleus of old people is supposed to drive out its quantum of water into the softer cortical, producing swelling of its lens fibres and their disorganization. The lens is then supposed to give off its soluble albumen freely to the aqueous humor, and to absorb from it excess of water. This leads to the swelling of the lens cortex, in the progress of cataract, and to reduction in depth of the anterior chamber. When the substance of the lens is opaque quite up to the capsule—when the cataract is said to be mature—a partial absorption of the softened cortical takes place, and the chamber deepens. If this process has gone on for years, the capsule comes to embrace a hard, dry nucleus, and adheres to it as if it were waxed. We call it then a *hypermature* cataract. Simultaneously with beginning senile cataract, patients often become *myopic*. Those that were *myopic* before the changes in the lens, become more so. This is doubtless due to the swelling of the lens during the cataractous alterations. Old people who find themselves laying aside their reading glasses for weaker, or even reading without any, have become *myopic*. In proportion as they acquire "second

sight" for reading, they see worse in the distance. Concave glasses then help them to see remote objects better, as they do with any myope. In many or most of these cases, there will be found incipient cataract, and, not infrequently, floating corpuscles in the vitreous, showing disturbed nutrition from choroidal irritation.

CONGENITAL CATARACT.—So-called cases of congenital cataract doubtless often begin very soon after birth, and before the infant shows any indication of how it sees. Congenital, or early infantile cataract, may be partial or complete. The partial embraces two varieties, the polar and the lamellar. The *polar* is nearly always at the anterior pole of the lens. There is seen a small, round, whitish opacity, in or near the centre of, and just within, the anterior capsule. When the anterior polar cataract is large and prominent, projecting beyond the plane of the pupil into the anterior chamber, it is called pyramidal. It was once thought that these opacities were deposits on the outer surface of the capsule. But the whole mass is within the capsule, which is pushed forwards. The pathology of these cases is simple: they can generally be traced to the same cause, that is, perforation of the cornea, though in very rare instances they cannot be explained in this way. In *ophthalmia neonatorum*, central and limited ulceration and perforation of one or both corneae, take place. The aqueous escaping, the anterior capsule comes against the cornea, and is agglutinated to it. When the aqueous is again retained, and the chamber re-established, the two surfaces are separated and the adhesion severed. By some means this temporary union causes proliferation of the intracapsular cells, and a limited and stationary opacity. Most frequently a small corneal opacity may be detected, indicating the seat of the perforation, and oblique illumination will nearly always reveal it. Of course, the history of purulent conjunctivitis will help to clear up the diagnosis.

Lamellar cataract (*Schichtstaar*, of Jaeger) begins in very early life, and presents such marked characteristics that it can hardly be mistaken. It corresponds to the axis of the lens, and hence centres with the pupil. The sharply defined, circular opacity of the lens may be less or larger than the average size of the pupil. It has a dull-grayish look, and by a careless examination might be supposed to involve the entire lens. Dilatation of the pupil, and oblique illumination, will show at once what it is. While the opacity is nearly or quite circular, and sharply defined, the edge is apt to be a little ragged or serrated. The opaque spot is back of the capsule, between it and the nucleus. The laminae next the capsule, the nucleus, and the entire periphery of the lens, are all clear. Rarely there is seen a corresponding opacity behind the nucleus, and of course deeper seated in the lens. Ophthalmoscopically, the dilated pupil is uniformly red, except the central opacity, which has a reddish-brown appearance, the centre letting more light through and looking redder. In the school period, such patients are often near-sighted, perhaps from the constant habit of holding the book close and straining the accommodation. Lamellar cataract, after reaching a certain point, becomes stationary, and generally remains so during life. Rarely its progress is renewed, leading to total cataract. The patient is usually brought for advice on account of supposed near-sightedness, because he holds small objects unduly close, to see them. He brings the book near his eyes because he does not see well, and not because he is myopic. Still, he often becomes so, as proved by the usual tests.

Either beginning *in utero*, or very soon after birth, a soft, milky-white, total cataract is sometimes seen, which usually involves both eyes. It has a tendency to become liquid, in later years, and may undergo partial or complete absorption, leaving only a dense, opaque capsular membrane. If neg-

lected until the child is ten or more years old, and then removed, good sight is seldom restored, although the vivid response of the pupil, and the quick perception of light, may have led the operator to expect and promise a good result. The retina never having exercised its functions, rapidly loses its capacity for perfect sight.

In youthful subjects, another form of cataract is occasionally seen, partial in the beginning, but progressing rapidly and leading to blindness of one or both eyes. Sometimes it starts in the nucleus and extends to the cortex. In other cases it is just the reverse, and the cataract has a peculiar, radiating, star-like appearance in the anterior cortical. In such persons the lens is more solid, and has sometimes a quite firm nucleus, especially if not operated on for many years.

SENILE CATARACT.—This is by far the most frequent variety, and the name indicates that it has for its victims people of riper years. The sclerosed nucleus in old persons is amber-colored, very firm, and dry, and it undergoes little change in senile cataract. The alteration is chiefly in the cortical portion, and begins usually at the periphery, in the form of little striæ, sometimes called *arcus senilis lentis*. Not affecting the sight in this incipient form, the striæ are not perceived by the patient, nor seen by the examiner, except rarely. At a later period they send out, towards the pole of the lens, little prolongations, like feathery frost crystals. These, reaching the area of the pupil, begin to disturb vision. In examining a great many people, I find that the marginal opacities usually begin at the lower and inner edge of the lens, and thence extend to the rest of its circumference. Little by little these marginal striæ multiply and extend towards the centre of the pupil, producing slowly increasing dimness of vision. As they widen, become confluent, and involve the whole cortical, which in the mean time becomes perceptibly swollen, the amber nucleus is more obscured, and the cataract is at last mature. We say that maturity is attained when the opacity involves the entire cortical, up to the capsule, so that the iris throws no visible shadow. In this stage, the opaque, soft cortical undergoes slow absorption; the anterior chamber deepens, and the amber nucleus again shows itself more plainly. Left so for a long time, the cataract becomes hypermature.

The progress of cataract in different patients is variable, but nearly always slow, requiring often many years to reach completion. Senile cataract attacks both eyes, but usually not at the same time. One is apt to progress faster, and get blind before the other. Cataract is never attended by pain or any inflammatory symptom whatever. If pain accompanies its development, glaucoma or some other grave complication is its explanation. The only discomfort, aside from the trouble in seeing, is manifested by shrinking from light, and efforts to turn the back towards it. Thus the eyes are shaded, the pupils dilate, there is less diffusion of light, and the patient sees better. He often finds relief in a broad-brimmed hat well down over the eyes. When the nucleus is more opaque than the margin, the patient sees better on cloudy days, before sunrise, or after sunset. If the reverse obtains, he sees better in the bright light. The pupil will be found active in response to light, the iris natural, and the tension of the globe normal; in short, no evidences of disease are present, except the cataract. In old people the pupil is smaller and less active than in early years, but it varies in different persons. While the ready response of the pupil to light is a good indication of the state of the retina, it is not infallible. In some cases of retinal detachment, its movements are energetic and misleading, while in other persons with a sound fundus, the pupil does not respond at all. There may be motor paralysis of the fibres of the third, or of the sympathetic. The degree of dilatability under atropine

varies, but it is always less than in youth. Large dilatation with mydriatics, in old people, is favorable.

TRAUMATIC CATARACT.—This class embraces all cataracts that directly follow injuries of the eye. There is nearly always a wound or rent in the capsule, by which the lens substance is exposed to the action of the aqueous. The dangers of traumatic cataract are much less in young people than in old. In the former, the absorbents are more active, and the lens is soft and ready to dissolve. The hard, dry lens of the aged, is not capable of absorption. In all cases, the course of the cataract will be influenced by the complications. If the cornea and iris have both been wounded, or if the injury be through the ciliary region especially, there will be great danger of loss of the eye. The additional lodgment of a foreign body in the eye, enhances the risks very greatly, unless the foreign body be lodged in the lens and can be extracted with it, when the prospect is far better than under other circumstances. If the lens has been luxated, as it is more apt to be in old subjects, the prognosis is most unfavorable. A very protracted course is certain, except when immediate extraction is effected. There is great danger of loss of vitreous, in such cases, if an operation is attempted, but without an operation, glaucomatous disorganization is very sure to follow. Even a free iridectomy often does not prevent loss of the eye, with endless suffering, and enucleation may at last become necessary. Prolapsus of the iris in traumatic cataract is a common and troublesome complication. If no other serious injury be present, and the patient be young, the cataract may entirely disappear, in a few weeks or months, by absorption, with recovery of useful vision. Even then the rent in the capsule may close, and a tough secondary cataract remain to seriously obstruct sight. Altogether, the prognosis of traumatic cataract is very unfavorable.

TREATMENT OF CATARACT.—The question of diagnosis and ripeness of cataract being settled, we interrogate the retina with a view to treatment. Nothing but surgical interference can do any good. If the retina be sound, even in the most dense cataracts, there will be prompt perception of light and accurate projection. We test these points in a dark room, with the use of a candle, as follows: The room should be from fifteen to twenty feet long, and well darkened. A single, lighted candle is held at one end of the room, and the patient faces it from the other, the eye not tested being well closed. If he can tell quickly, when the candle is darkened by the hand, and suddenly uncovered, his central perception is good. But that is not enough. Enforcing stillness of the eye in one direction, the *covered* candle is carried to the left, right, above and below, in the field of vision. In each new position, the light is suddenly uncovered. If he sees and can point to it, without turning the eye, the field is intact and the projection good. Defects in the field, more or less complete and large, indicating detachment of the retina, choroidal patches, or other serious lesions, excite great doubts as to the probable success of an operation, or perhaps forbid it entirely. Slow and uncertain perception in the line of vision, is a very bad indication. The *distance* at which a candle can be discerned, is a good test of central acuity. If the light must be brought very close before it can be recognized, the prognosis is bad, and if not perceived at all, hopeless. The ophthalmoscope may be used for the same trial. By turning the lamp low, and then throwing the light on the pupil, from different directions, the ready perception and integrity of the field may also be established.

Not only must an intelligent diagnosis of the state of perception, and the integrity of the visual field, be made out; but other questions must be settled,

before resorting to a surgical operation. Let us assume that cataract exists and is fully matured, and that the functional examination of the retina is satisfactory. But only one eye is involved. Monocular cataract, unless traumatic, is not common, and it is always wise to wait a year or more, to see if the other eye will remain unaffected. If it do, and if the subject be young, an operation may be advisable. In senile cataract, with one eye still intact, I would emphatically decide against any operation, till incipient lenticular changes had begun in the sound and seeing eye. After that, I should leave it to the choice of the patient, whether to wait till it too was nearly or quite blind, or not. It must be remembered that no operation for cataract is free from serious risks. A patient advanced in years, with one good eye, had better endure the inconvenience of one-sided blindness, to which he soon becomes accustomed, than incur the dangers of an extraction. Should all go well, and the best possible result be secured, the sight is so much inferior to that of the other eye, that the patient does not usually appreciate the gain. Should an unforeseen accident occur during the operation, or should disastrous reaction follow it, the eye will probably be lost, with sympathetic danger to the other. In a young person, with a prospect of long life, and where a less risky procedure may be resorted to, one may cautiously advise it for the sake of looks, and to relieve the patient from the inconvenience of a blind side.

Another question is, whether if both eyes are blind and ready for operation, it is wise to operate on both at the same sitting. In children it is proper. In adults, as a rule, it is safer to take one at a time, leaving a few days, or longer, between the operations. Still another point of conscience is this. Suppose one eye has been operated on with success, the patient being able to read well and conduct his business: Is it then advisable to operate upon the other? I would say no, unless at the urgent request of the patient, and after fully advising him of the possible disasters. I shall never forget the case of an old gentleman from one of whose eyes I extracted the lens with perfect success. One week after, at his instigation, I repeated the operation upon the other eye. All went well, at the time, and for a few days. Then iridocyclitis set in, from which he lost this eye, and was soon blinded in the other from sympathetic ophthalmia. The same thing may happen to an eye not yet operated on, and not even cataractous, from a painful failure in the first operation. Who, of large experience, has not met with this misfortune? Surgeons and physicians generally have very trivial notions of the delicacy and seriousness of cataract operations—an opinion which is confirmed by the publication of successful cases only, as personal advertisements, rather than in the interest of the healing art.

Operation by Solution, or the Needle Operation.—There are but two operations now practised for cataract: solution and extraction. The former is applicable only to soft and absorbable cataracts, as they are met with in children, and in persons under twenty years. The subject young and healthy, the entire lens involved, and the little patient reasonably tractable, this operation is attended by slight risks and promises well. The pupil is to be well dilated by atropine, and the patient put in a good light, on a lounge, bed, or operating table, and rendered thoroughly insensible with ether; the stop-speculum¹ is then introduced, and the eye fixed by the large, toothed, fixation forceps² held by the left hand. The right holds the small stop-needle (Figs. 923, 924), passes it carefully through the cornea, about half way between its centre and external margin, towards the lens capsule, carefully watching the point to see when it pierces the latter, and to avoid going deeply into the lens. Then by a quick elevation of the handle, the cornea acting as fulcrum, the capsule is

¹ See Fig. 921, page 591, *supra*.

² See Fig. 922, page 591, *supra*.

divided transversely to a short distance. Then the needle, being slightly retracted, may be advanced so as to make a second incision in the capsule, at right angles to the first. In that way, the elastic capsule being incised crucially, the points retract and leave a small portion of the lens exposed

Fig. 923.

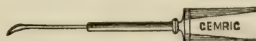


Fig. 924.



Bowman's stop-needles, curved and straight.

to the contact of the aqueous. The lens imbibes the humor, swells, breaks down slowly, and at last is dissolved by the aqueous, leaving a clear pupil where the capsule was opened. Usually the rent closes, after a few weeks or months, and the solution ceases. Then the manœuvre must be repeated till the pupil is free from obstruction. The needling process may need to be repeated several times, and the restoration to sight can only be expected in the course of many weeks or even months.

It must be remembered that the intra-capsular cells always swell, multiply, and produce a thickening of the capsule around the rent, as the lens substance itself dissolves. A grayish-white opacity will be seen in the capsule, and, in case the rent closes, it will be found much tougher at the second and third punctures, than at the first. Indeed, it will often be found necessary to use two needles, in order to tear it sufficiently, introducing one inwards and the other outwards, passing them through the tough membrane at the same place, and then separating their points by suitable movements of the handles. If the first incision be too large, and the lens swell rapidly, pressing against the iris and giving rise to acute plastic iritis, with perhaps glaucomatous hardness of the eyeball, an incision must be made in the cornea with a spear-knife, and the softened lens must be extracted. It will readily come out with the aqueous, assisted by a spoon.

For a few days or even weeks after a needle operation, the patient must be kept quiet in a moderately darkened room, for fear of dangerous reaction. If pain, tenderness to light, weeping, and ciliary injection come on, cold applications, and the energetic use of atropine, are the best remedies. In all cases, the eye must be daily tested as to tension. If that becomes excessive, repeated paracentesis must be employed, and, if need be, a linear extraction of the soft and swollen lens. The pupil must be kept well dilated during the whole course of treatment, so as to withdraw the iris from contact with the swelling lens.

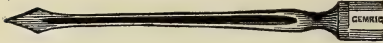
Traumatic cataract, in young subjects, may be treated in the manner above described, but if a foreign body be lodged in the eye, the danger of the operation is greatly increased. Should the foreign body be seen in the lens, they may both be extracted together by a linear, corneal incision. In lamellar and polar cataracts, the vision, if possible, should be improved by a small iridectomy, which is almost free from danger. If dilatation of the pupil improves the sight materially, a well-executed, small iridectomy will help still more. As these cases are partial and stationary, if reading vision can be secured, it is vastly safer and surer than a cataract operation, in which the danger of excessive swelling is very great. If the entire lens is liquid, a broad needle¹ may be used to puncture the capsule. Before being withdrawn it should be slightly rotated, and the fluid lens allowed to escape with the aqueous. A grooved needle (Fig. 925) may also be employed.

In older subjects, where the nucleus is a little firmer, but not hard, a

¹ See Fig. 920, page 591, *supra*.

linear extraction is preferable. For this purpose the pupil must be widely dilated, the stop-speculum introduced, and the eye well fixed, the patient being under ether. A broad spear-knife, or keratome (Figs. 926, 927), is passed through the cornea, midway between centre and margin, so as to open the

Fig. 925.



Grooved needle for fluid cataract.

Fig. 928.



Cystotome.

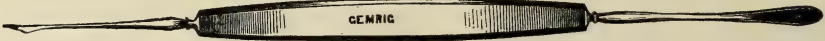
Figs. 926, 927.



Jaeger's keratomes.

chamber by an incision five or six mm. in length. A cystotome (Fig. 928), passed very carefully through this incision, opens the capsule freely. Then while the outer lip is pressed gently back by a small curette (Fig. 929), an-

Fig. 929.



Paracentesis needle and curette.

other is lightly pressed on the opposite side of the cornea, and the lens made to come slowly out in fragments. If discission has previously been practised, or if a traumatic cataract demands this operation, the cystotome is usually not needed at all. Great care must be taken to avoid prolapsus of the iris during this operation. If it occurs, and is not readily reduced with the spud,¹ or by gentle closure of the lids and rubbing over the cornea with the finger, aided by eserine, it must be gently drawn out and snipped off close to the cornea. The future welfare of the eye demands that no iris shall be left in the corneal incision; and this provision applies to all forms of extraction.

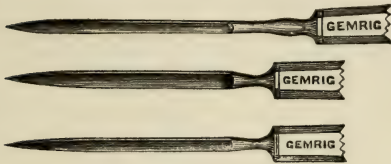
Graefe's Operation, by Modified Linear Extraction.—In *senile cataracts*, extraction is the only allowable operation. Since the general abandonment of the old corneal-flap method, some form of Graefe's *modified linear extraction* is usually adopted. But each one practises the method of the great innovator with his own favorite deviations. This operation necessitates an *iridectomy*, which is a mutilation much to be regretted. But as its advantages more than compensate for the resulting deformity and less perfect vision, it should be accepted. The unanimous opinion of operators is that an incision at or a little in front of the sclero-corneal junction, is safer than one farther back and very close to the iris, as originally practised. Prof. Arlt, and a few others, still prefer to cut out under the conjunctiva, so as to get a protecting flap from it. The tendency, however, is to come out more in the cornea, and two methods are practised in which the deviation from the original operation is very great.

My own experience leads me to operate about as follows: I greatly prefer not to give ether, and only resort to it with extremely nervous or cowardly patients. The best preparation for this operation is *no preparation*, taking the patient in his usual health, and without waiting for him to work himself up into a mental stew of anxiety. As the patient must keep his bed for a few

¹ See Fig. 919, page 591, *supra*.

days, a good spring mattress should be provided. The patient is put comfortably in bed, in front of an unobstructed window, with a good light. There must be no head-board, or the head of the patient must be put to the foot of the bed, so that the operator or assistant may stand behind and meet with no impediment. The bed must be so placed that a direct and clear view of the cornea, without any disturbing reflex, may be secured, and no hand or head must be allowed to come before it. I prefer to operate without dilatation of the pupil. A suitable stop-speculum, fixation forceps, a Graefe's knife (Fig.

Fig. 930.



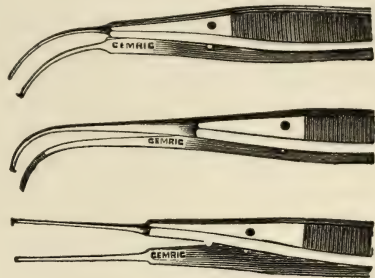
Graefe's cataract knives.

Fig. 931.



Graefe's tortoise-shell spoon.

Fig. 932.



Different forms of iris forceps.

Fig. 933.



Iris-scissors.

930), a cystotome with a hard-rubber or tortoise-shell spoon on one end (Fig. 931), a small curved pair of iris-forceps (Fig. 932), and a small pair of scissors (Fig. 933), curved on the flat, are the necessary instruments. Borated cotton, soft rags, and a bandage must be at hand. It is wise to have a strong solution of boracic acid, into which all the instruments should be dipped, and with which the eye should be well washed out. I have never operated under the spray, and consider it a vapory refinement. All things being ready, I talk kindly and frankly with the patient, telling him what to do and what not to do. He must promise to keep his mouth shut, not to hold his breath, and to listen to what the operator says, doing quietly as he directs. If he will keep his wits about him, and not resist, all will go more safely and easily. I never risk changing the fixation forceps to other hands, but hold them exclusively myself.

In extracting from the right eye, I stand or sit behind the recumbent patient's head, making the section with my right hand. Exchanging the knife for the iris-forceps, I draw the iris out, to be snipped off by the assistant. That done, I use the cystotome, and then turning the spoon end, make gentle pressure at the lower sclero-corneal junction, to bring out the lens. To operate on the left eye and still use my right hand, I sit on the side of the patient, directing him to put his left arm around me, so that I can get close in to his body. The assistant then stands behind his head, with the iris-forceps and scissors, draws out the iris with his left hand, and snips it with the right.

Then exchanging for the cystotome, he cuts the capsule and instantly hands me the spoon, which I use in bringing out the lens. In this case I can, and sometimes do, use the iris-forceps and the cystotome myself, the assistant simply snipping the iris. But the position is a little constrained, and I prefer the first method. To fix the eye, I use the large, broad-toothed forceps,¹ without spring to hold them closed, opening them three or four mm., and pressing them firmly on the ball, at the sclero-corneal junction, and then closing them so as to get a firm and controlling fixation. The point of fixing is not vertically below the cornea, but downwards and inwards, the extraction being usually upwards. I do this to better avoid the rolling of the eye on its visual axis, during puncture and counter-puncture. In old people with friable tissues, the conjunctiva sometimes tears, but it is not apt to do so if solidly and deeply held. I generally use the original stop-speculum of Graefe, and in case the eye is prominent, with danger of pressure, I direct a second assistant to hold the instrument near its temporal end and lift it slightly forwards. The smaller speculum, turned towards the nose side, is less in the way of the operator.

It is difficult, in describing this operation, to designate accurately the points of puncture and counter-puncture. Assuming, as an average, that the horizontal diameter of the clear cornea is twelve mm., I would say, let them both be exactly at the sclero-corneal junction, and one mm. above this diameter. In that way an incision of ten or ten and one-half mm. may be obtained, even if the knife cuts out a little in the transparent cornea. In passing the knife, I go straight through, without changing the direction of the point, simply watching it closely so as to make the counter-puncture at the right place. One is apt to make it further back than the point of entrance. This is a less dangerous mistake than the opposite, which gives too small an incision for the easy exit of the lens. The extent of the incision may be somewhat regulated by the approximately determined hardness of the lens and size of the nucleus. But there are always much greater dangers and difficulties connected with a too small, than with an unnecessarily long incision. These preliminaries settled, the steps of the operation may be briefly described. The knife should be introduced and kept with its surface parallel with the iris, being pushed far forwards, after the counter-puncture is made, so as nearly to complete the section, which is then finished as the blade is slowly withdrawn. Holding the cornea straight forwards or a little divergent, aids very much in this act. If the point of the knife catches slightly in the iris as it passes through the chamber, or if the iris falls over the edge, it is better to go right on and finish, than to hesitate and retract. Just before finishing the flap, it is best to turn the edge of the blade slightly forwards. In rare cases, where the eye is very deep-seated, the knife may be passed in with the edge inclined somewhat forward from the start, and made to cut out in the same plane, so as to prevent haggling of the wound. In that case we cut out farther forwards in the cornea. The section completed, we proceed at once to the iridectomy. If the iris prolapses, as it nearly always will, it needs only be seized, held firmly, drawn slowly out, and snipped off at one angle of the wound as close as possible. It is then drawn on a little more, carried towards the other angle and again snipped. On completing the excision, the angles of the wound are quickly inspected, and if any trace of iris hangs in either, it must be carefully seized with the fine forceps, drawn out again, and snipped close to the surface. If neither branch of the iris is drawn into the cornea, the straight, cut edges can be quickly recognized in the anterior chamber.

The next step, dissection of the capsule, should be done quickly, so as to

¹ See Fig. 222, page 591, *supra*.

anticipate hemorrhage into the chamber. The very sharp cystotome, inserted flatwise with its point slightly upwards, is passed carefully down on the anterior capsule, till it reaches, or even passes behind, the lower edge of the pupil. Then, turning the point towards the capsule, it is drawn lightly upwards to the edge of the lens, making a vertical and long incision. This done, the curette or tortoise-shell spoon is placed with its convex surface against the lower edge of the cornea, and gentle pressure is made backwards. If in a moment the wound gapes, showing that the lens is engaging, the scoop may be slid slowly upwards over the cornea, till the lens escapes. Great gentleness is required at the last, to avoid loss of vitreous before the speculum can be removed. The moment the lens escapes, the stop must be loosed, the branches carefully brought together, and the speculum removed with great quickness and skill, so as not to press the eye. As a rule, I hold the eye with the fixation forceps till the lens escapes, and then instantly let go. In prominent eyes, or when escape of vitreous is imminent, we may let go the eye and remove the speculum the moment the iridectomy is finished and the capsule divided. Then closing the eye with a wad of charpie or cotton, for a few seconds, the lids are cautiously separated by the fingers, and by means of pressure through the lower lid the lens is made to escape. Or, the lower lid being well drawn down, the scoop may be used for pressure.

After the exit of the lens, the eye is shut for a few minutes, with a mass of cotton gently pressed on the closed lids. Then carefully opening it, a critical inspection of the pupil is made, to see if any soft cortical is left behind. If so, it must be carefully worked out, so as to secure a clear black pupil. To do this, request the patient to turn the eye down and try to hold it there. Then raising the upper lid above the incision, make careful sliding movements over the cornea from below upwards, through the medium of the lower lid. In this way the fragments may be slowly and very carefully coaxed out. If one or two trials do not succeed, let the eye be closed with a soft compress and bandage, for half an hour or more, till the aqueous reaccumulates. Then the same manœuvre will probably float out the soft fragments. The success of the operation will depend largely upon the ability to get away all the fragments from the chamber, and secure the most perfect coaptation of the incision. If any strings of coagulum, or shreds of capsule, hang in the wound, they must be removed with the small forceps. Without all these precautions, union by first intention cannot be expected, and the operation will be a more or less complete failure. The section should be ample and regular, and no iris or prolapsed capsule should be left in the cut.

If a black pupil, free from blood, is secured, it is wise to test the vision by letting the patient count your fingers. Finally, both eyes should be closed by a roller so as to preserve their most perfect rest. A piece of old, soft cloth, large enough to cover both eyes, and torn at one edge to adapt it to the nose, is first adjusted. Then pellets of cotton are put over the eyes, to fill out the inequalities and make uniform pressure, and are followed by the application of the roller, which must not be tight enough to cause pain. For five or six hours, the patient, if possible, must lie very still, and flat on his back. If by that time, the bandage is at all deranged, let it be readjusted, without opening the eyes, and let the patient be kept quietly on his back till morning. Fresh dressings and bandage are then applied. On removing the soiled ones, if the lids are free from puffiness and the pads dry, all is well, and the eye should not be opened. Some swelling of the lids and yellowish discharge indicate dangerous reaction, and the eye should then be opened and inspected. In case the patient suffers little or no pain, and all looks promising, the dressings should be changed twice a day for two or three days, before opening and inspecting the eye. A careful night-nurse should watch the patient in sleep,

to see that he does not hurt the eye. In a week or ten days the bandage may be removed, and a double compress be hung over the eyes, or a broad shade substituted. The room should be kept comfortably dark for some days after the operation, and the eye gradually accustomed to light. If all goes well, the patient may leave his room in about two weeks. If now a three and one-half inch lens improves the vision greatly, a good result is almost certain.

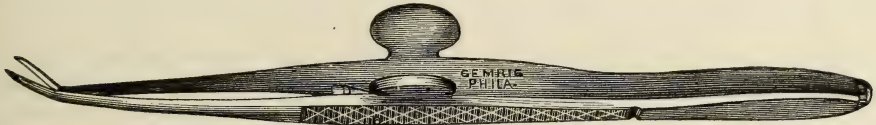
There are some troublesome accidents which no amount of experience and skill can always avoid. One of these is obstinate *hemorrhage* into the chamber, causing great difficulty in dividing the capsule, and perhaps preventing immediate vision. If the blood gathers in the chamber before the capsule has been opened, it may perhaps be coaxed out by a few strokes of the moistened curette. If not, the capsulotomy must be made by guess, carefully avoiding injury to the iris. If the chamber fills with blood after the exit of the lens, it will perhaps escape with the lens fragments under the sliding movement. If not, it can be safely left to the absorbents. *Loss of vitreous* before the escape of the lens is a very serious disaster, as it necessarily displaces the lens and makes its removal extremely precarious. A slight loss of vitreous following the lens, or in the sliding manœuvre to clear the chamber, is not so serious. Still, such loss always increases the immediate and remote risks. When the cataract is hypermature, or the incision too small, or both, the *presentation* may not be prompt. If this be due to the smallness of the section, that must be enlarged with the knife or the iris scissors, a procedure requiring great coolness and skill. Should the incision be free enough, and should the edge of the lens yet not come forward and open the wound, on moderate pressure with the scoop, the cystotome may be lightly passed in, its edge well forward, and drawn along the wound so as to divide the anterior capsule freely along the lens margin. Then the same pressure will eliminate it without serious trouble. If *suppurative reaction* comes on in twenty-four hours after an extraction, the eye will generally be totally lost. A milder reaction, at a later period, always protracts the cure, and generally leads to a membranous formation in the pupil, with imperfect vision. The suppuration begins in the corneal wound, at either end or in the middle, and thence proceeds to the iris and even the ciliary body. Careful springing of the incision once or twice a day, the free use of boracic-acid solution in the eye, the instillation of atropia two or three times a day, and the application of cold compresses externally, seem to be the best means of checking this sad process. In very old or feeble patients, warm fomentations or poultices do better than cold. Such cases, at best, end in closed pupil and a retracted cicatrix. In the worst forms, shrinking of the eyeball and even sympathetic danger to the fellow eye, may be the result. There is a well-grounded fear of sympathetic ophthalmia following the original operation of Von Graefe, where the section is made in the anterior part of the sclera, close to the periphery of the iris. The nearness of such a wound to the dangerous ciliary region, leads to greater risk of cyclitis and consequent sympathetic inflammation. Experience has led most operators to deviate from the classic method, and to make the incision at the base of the clear cornea, or even further forwards.

There is a popular impression that even after the most perfect success the cataract may return. This belief is based on the fact that sometimes the sight fails again in a year or two, very seriously. For example, with a vision of one-half, and the ability to read the finest print with ease, a mist slowly comes over the eye till the patient can only see to walk. This gradual clouding of sight is explained when the pupil is inspected by the ophthalmoscope, and by oblique illumination. A thin, grayish, filmy membrane is seen covering the originally clear pupil. This is not a reproduction of the

lens, but a thin formation filling the rent in the capsule. In some cases this condition calls for relief, but if fair reading capacity is still left, I prefer to let the eye alone; otherwise, another operation is required.

These *secondary operations* to clear the pupil are by no means free from the risk of dangerous reaction. The thicker this capsular obstruction, and the longer it has existed, the tougher it will be, and the greater the difficulties and dangers of the operation. A very sharp sickle-needle may be passed through the cornea, and made to penetrate the capsule and incise it centrally. Or a Graefe's knife may be used for the same purpose. A safer and better method still, is that of Bowman's two stop-needles. One is passed through from the outer side, the other from the inner, both being made to pierce the obstruction at the same central point; then by a leverage motion of the handles, the needles are made to separate, each supporting the capsule for the other, and a central rent is made, with immediate clearing of sight. To do this with the greatest precision requires artificial oblique illumination. When the obstruction is thick, tough, and on a level with the iris, to which it may be adherent, a free incision with Wecker's scissors is the safest and surest remedy. A narrow

Fig. 934.



Wecker's scissors, modified by Keyser.

spear-knife is made to puncture the cornea, and the closed scissors passed through the incision. As they are opened in the chamber, the pointed blade backwards, the obstruction is pierced and the blades pushed forwards, and then closed, so as to incise it freely in its centre. If it is cut at right angles to the direction of the greatest traction, the incision will open enough by its own elasticity. In some cases, with closed pupil and dense false membrane adherent to the iris, an iridectomy may be practised. In that event, however, a firm, pigmented, false membrane is seen behind the new pupil, and another operation will be required. I prefer to cut the whole structures at once by a free sweep of Wecker's *pince-ciseaux*.

In all these secondary operations, the danger of violent reaction comes from traction on the ciliary processes, in efforts to tear or incise the tough obstacle. For that reason, a skilful, two-needle operation, or an incision, is the least risky. After any of these operations the eye must be closed with a soft pad and bandage, and the patient kept quiet in a darkened room for a few days. Cold water applications, and anodynes internally, are the best remedies. Atropine, except in very filmy obstructions, without synechia posterior, is not beneficial. If persistent iridocyclitis, with pain, tenderness to the touch, and threatening sympathetic indications in the other eye, result from a cataract extraction, the offending organ must be enucleated. All these observations, based on the facts of experience, show that cataract operations of all kinds are not free from grave risks.

The lens in all cataract operations is destroyed; the eye is deprived of its accommodation, and is rendered extremely hyperopic. Suitable cataract lenses must then be worn for all purposes. If the proper glass does not help the sight very greatly, the pupil is not free from obstruction, or the visual capacity is impaired. Practically, two lenses suffice—one weaker ($3\frac{1}{2}$ to 4 inches focus), for distance, and one stronger (2 to $2\frac{1}{2}$), for reading and other close work. If the curvature of the cornea has been changed by the operation, a

cylindrical lens may often be combined with the spherical with very great benefit. Cataract glasses are worn in heavy frames, as any other spectacles. It is better to wait six weeks or more before accurate trials are made to adapt the glasses, but a walking lens of four inches may be worn till that time if necessary. Great prudence in the use and the exposure of the eyes is required for months after the operation.

As already mentioned, the lens may be luxated in the eye, either from an injury or spontaneously. If this displacement takes place in the vitreous, leaving a free pupil and causing no destructive irritation, useful vision may be enjoyed by the aid of a cataract glass. If increased tension results, the glaucomatous hardness and threatened loss of sight may be relieved by a very careful iridectomy. Even an extraction may sometimes be practised, but at the risk of great loss of vitreous. In case all saving measures fail, the painful eye must be enucleated. Should the lens be knocked into the anterior chamber, or fall through the pupil, extraction is imperative. Spontaneous luxation of the lens is often seen in *coloboma* of the iris, with defective development of the zone of Zinn. I recall several curious cases of this kind. But even in the absence of any congenital deformity of the eye, family peculiarities exist which predispose to spontaneous luxation.

I have now under treatment a man, 48 years old. He felt some trouble in the right eye after lifting, and called for advice. There was ectopia of the lens downwards, the edge showing in the pupil, but with no pain or irritation. With a weak cataract lens the vision was two-fifths. At first the edge of the lens was at the centre of the pupil, but in three or four days the displacement downwards was complete; the eye remained comfortable, and the sight the same, for some months. Then one day, while he was stooping over a shrub, the eye was struck by the end of a twig; four days afterwards the eye was painful, tender to light, and weeping, the ball sore to the touch, with marked ciliary injection and discoloration of the iris, but no increase of tension. I prescribed a weak solution of atropine, and enjoined quiet. Next morning the eye was much better in all respects; but the same afternoon, while stooping for a book, he felt something "give way," and was suddenly blind. I found the lens, inclosed in its capsule and partially cataractous, in the anterior chamber. He was kept quiet for twenty-four hours, under the local use of eserine, and then the lens was extracted by a large corneal incision downwards. No vitreous was lost, but the iris prolapsed very slightly, the protruding portion being then snipped off. For some days the patient was kept in bed, and suffered a good deal of pain, but he recovered, with extraordinary vision, by the aid of a $+S\ 9\ d.$ $\odot + C\ 3\ d$ $A\ 45$, $V = \frac{1}{10}$. In his left eye, with a myopia of 6 d., he has a vision of $\frac{4}{10}$, the iris being tremulous, and there being some striæ of opacity in the lower and inner edge of the lens. Luxation will take place in this eye at some future time. In his family are five brothers and five sisters, seven of the ten having perfect eyes. One brother has a healthy emmetropic right eye, but in the left there is a complete luxation outwards, with confirmed glaucoma and hopeless blindness, the eye remaining comfortable. A sister has also one good eye, and one with luxation of the lens into the vitreous.

GLAUCOMA.

The essential characteristic of the fatal group of symptoms, called *glaucoma*, is increased hardness of the globe. The strong maintaining tunic is composed of the sclera and cornea. These two parts, physically so different, histologically are directly continuous, the fibres simply becoming transparent when passing into the cornea, and *vice versa*. When naturally distended by the inclosed transparent media, and the blood pressure of the choroidal and retinal vessels, the sensation given to the finger is called "normal tension." The healthy tone or elasticity of the eye, and the various deviations, can only

be recognized by an educated finger. Education, here and elsewhere, is a tedious process, acquired and preserved only by constant practice. But how is the touch to be applied in this delicate investigation? The eye to be tested must be gently closed, turned towards the floor, and the head held slightly backwards. In this quiet way, the surgeon, sitting, facing the patient and in easy command of his own hands and arms, places the two index fingers, close together, on the globe of the eye above. The undivided attention must now be transferred to the pulps of these two fingers. While one is pressed with some firmness on the ball and held still, intermitting pressure is made with the other, as in feeling for fluctuation. The quiet finger detects the rise and fall of the fluctuating contents of the globe. The pressure should be directed perpendicularly to the surface, but not hard enough to produce pain. The natural eye is yielding and elastic. In high degrees of morbid tension it may be stony hard.

A convenient system of abbreviations has been adopted, to express the degree of tension: T_n , tension normal; $T?$, tension doubtful; T_{+1} , T_{+2} , T_{+3} , indicate increased tension; T_- , tension diminished; and T_{-1-2-3} , three degrees of softening. When there is great increase of intra-ocular tension, or the reverse, it is easily recognized. But slighter variations require great tact and attention. Both eyes should be examined in quick succession, transferring the fingers from one to the other. The hardness of glaucoma often varies at short intervals. The test should be applied every day, or oftener, so as to surely detect this important symptom at the earliest possible period, and watch its varying degrees. It is difficult to conceive how this pathognomonic symptom is brought about, except by hypersecretion of intra-ocular fluids, or by diminished exosmosis, or by both together. When these two processes are balanced in the nutritive changes within the eye, normal tension results. A natural secretion, with obstructed outward current, might produce increased tension. Hypersecretion, with free outward flow, might cause the same thing. But these two diseased conditions are usually united. What is the immediate cause, and whence the source, of this excessive secretion? Where is the seat, and what is the pathology, of the retarded exosmosis? Theories, and *facts to suit*, are by no means wanting. But none yet proposed, explains all the conditions of the glaucomatous process. Even the essential *fact* of glaucoma, increased tension, urged by Von Graefe as a satisfactory explanation of all the phenomena, has recently been denied. While perhaps always present in the advanced stage, it is said to be not essential to the existence of glaucoma, and not an initial symptom. The immense weight of authority, however, is on the other side, the differences of opinion being as to the origin of the increased pressure. Is the process a neurosis, or an inflammation, or both? The first was assumed by Donders as the best explanation. Others, claiming to have found traces of inflammation in the uveal tract and in the optic nerve, have put this forward as the forming stage, antedating increased tension. Increase in size of the lens, swelling of the ciliary processes, and diminution of the marginal space between the two, have been considered the first step in this disease. Retardation in the outflow of fluids from the eye, at the angle of the anterior chamber, followed necessarily by increased tension, explains the other phenomena. It is generally conceded that in most cases of glaucoma, there is compression of the angle of the anterior chamber, by a drawing forward and adhesion of the outer rim of the iris to the trabeculae of Fontana's spaces. In this way a check of the current of intra-ocular fluids towards the canal of Schlemm and the surface of the eye, is produced. But whether this is primary and causal, or secondary, is still a much disputed question.

But with all this theoretical bewilderment, there is a sad general agree-

ment in the prognosis, and the urgent necessity of surgical treatment in most cases. Just *how* an iridectomy or sclerotomy permanently relieves this fatal pressure, is as little understood now as in the time of Von Graefe. For accuracy of description, glaucoma is divided into simple, acute, chronic inflammatory, secondary, and hemorrhagic.

SIMPLE GLAUCOMA is chronic and insidious in its course, with very slow failure of sight, and is not attended by pain or inflammatory indications. For these reasons it generally escapes detection till the sight of one or both eyes is much impaired. The patient has always had an unaccountable difficulty in getting satisfactory glasses, has had to change them often for stronger ones, and at last cannot see much with any. If before, or at this time, he has sought medical advice, he has probably been told that his disease was cataract, and that he could not be operated upon till he was blind!

As glaucoma and cataract often exist together, and are both especially diseases of advanced years, this fatal error of diagnosis is all the more easy and common. The senile change of color in the lens to a grayish or amber hue, whether the eye is glaucomatous or not, readily imposes on the careless or incompetent surgeon.

In addition to rapid failure of accommodation and trouble with glasses, smokiness of vision, fluctuating but slowly increasing, comes on, and the patient remarks a colored halo around the lamp or candle at night. These vague troubles often persist for years before he seeks competent advice, and is told that he is going hopelessly blind. If vision is already greatly reduced, the pupil will be unduly large, and sluggish in response to light. The anterior chamber is shallow, the tension exaggerated, visual acuity diminished, and the field of vision contracted, sometimes concentrically, but usually more on the nasal side. Rarely there may be a central scotoma.

In this form of glaucoma, the humors are perfectly clear, and a most important ophthalmoscopic symptom is detected. I mean *cupping of the optic disk*. The eye end of the optic nerve yields to the increased internal pressure, and gives rise to this characteristic symptom. The cup or excavation involves the entire disk, or nearly so, and looks very different from the small central pit present in all healthy eyes. The edges are abrupt, and the main trunks of the retinal vessels seem suddenly cut off, as though cut out with a punch. Those who explain this symptom by a retraction of the optic nerve from previous inflammation in its sheath and texture, of course attach less importance to the pressure. As the few large trunks of the retinal vessels radiate from the optic-nerve centre, when this surface is pressed back and converted into a pit, these vessels will be suddenly bent as they dip down into it. The bottom of this pit being out of focus when the edges are in focus, they seem to be cut off. But when the bottom is focused, they are distinctly seen going to its centre, and, by looking obliquely, they may be traced down the abrupt sides. The difference in the glasses required to bring into sharp view the retinal margin of the excavation and the bottom of the cup, is an accurate measure of its depth. Another symptom, often present, is visible pulsation of the arterial trunks on the disk. If this is not seen spontaneously, it may be developed by very slight pressure on the ball with the finger. Swelling and falling of the veins, synchronous with the heart's movements, may often be seen in healthy eyes, but pulsation of the arteries is never seen except in disease. Undoubted hardness of the eye to the finger, cupping of the disk, and pulsation of the retinal arteries, are infallible evidences of glaucoma. Of course, the history and other symptoms mentioned, must not be forgotten. The lamina cribrosa of the sclera resists more in some than in others, and hence the cup varies in depth even with the same pressure.

At times enormous cups may be detected, with slight increase of tension, and at others extreme hardness and great damage to sight, with little or no pit. If the pressure has come on very slowly, the vision fails less rapidly. The damage to sight is due to the paralyzing effect of undue pressure on the conducting fibres of the optic nerve, their sudden flexure in the pit, and the impaired retinal blood supply. Mauthner denies this usual explanation, and insists that the functional failure is due to disease of the choroid affecting the rods and cones of the retina. Sometimes the natural brilliancy of the iris, the activity and average size of the pupil, and the outward appearance of the eye are so little changed, that the increased hardness, cupping of the disk, and failure of vision, are the only positive symptoms. But these are sufficient to settle the diagnosis. While glaucoma simplex may last for years and lead to total blindness without any inflammation at all, this painful complication is apt to occur, especially in the advanced stages of the disease, when it adds to the torment of the hopeless loss of sight.

ACUTE GLAUCOMA is always inflammatory, and often excessively painful, extinguishing sight in a few hours or days. The epithelium of the cornea is altered, the aqueous turbid, and the vitreous cloudy and showing floating corpuscles, so that the fundus cannot be seen with the ophthalmoscope. Intense episcleral injection, chemosis, puffiness of the lids, and excruciating pains in the eye, circumorbital region, and head, with perhaps nausea and vomiting, make up the frightful picture. Of course the ball is intensely hard, with insensibility of the cornea to light touches with a brush or probe. Indeed, anaesthesia of the cornea is present in greater or less degree in all forms of glaucoma. It is due to paralysis of the sensory corneal nerves from pressure. Acute glaucoma is sometimes preceded, for weeks or months, by prodromic symptoms, such as temporary blurring of vision with increase of tension, some vague feeling of discomfort or actual pain, and more or less injection. These significant symptoms intermit, leaving the sight better in the intervals. But they come oftener, last longer, leave the sight each time worse than before, and end at last in a destructive attack of acute inflammation. More rarely, the disease bursts out in all its violence without previous warning, in *glaucoma fulminans*.

CHRONIC INFLAMMATORY GLAUCOMA develops slowly like the simple variety, but always with symptoms of vascular reaction. With the peculiar hardness of the eye, there are cupping of the disk and pulsation of the arteries, if the humors are clear enough to admit of ophthalmoscopic examination. Beginning in one eye, it finally attacks both, but sometimes after a very long interval. Von Graefe believed that the occurrence of the disease in the second eye was hastened by iridectomy in the first. I believe this to be a mere coincidence, but the non-affected eye should be constantly watched, so that an iridectomy may be resorted to at once, if the necessity should arise. The varicose, insinuating loops of bloodvessels around the cornea, are very striking in the inflammatory forms of glaucoma. The advanced stages of all the varieties, when sight is extinguished, the ball stony hard, the pupil widely dilated, the iris atrophied and reduced to a narrow rim, the sclera of a grayish, leaden color, with large loops of tortuous veins, loss of tactile feeling in the cornea, and often cataract, are called *glaucoma absolutum*. In this pitiable condition, repeated and painful intra-ocular hemorrhages take place, the insensible cornea may slough, and the eyes may be reduced by atrophy of the globe. In the absolute glaucoma which follows the simple variety, the deep excavation of the optic nerve and excessive tension may be the only means of distinguishing it from hopeless atrophy of the optic nerve.

SECONDARY GLAUCOMA.—In the former varieties, the destructive hardness, with its long list of fatal consequences, seems to be *primary*. In this it develops in the course of numerous other diseases, and is hence called *secondary*. A frequent causal connection exists between increased tension and synechia anterior from perforating ulcers of the cornea. Luxation of the lens, spontaneous or traumatic, almost surely leads to glaucomatous manifestations, probably through irritation of the iris and the choroidal tract; and so may fragments of a broken-up lens. Total synechia posterior, cutting off communication between the two aqueous chambers, generally leads to destruction of sight from glaucoma. Serous iridochoroiditis is very apt to lead to secondary glaucoma. Intra-ocular tumors of all kinds give rise to increased tension at a certain stage of their growth. In all forms of ectasia of the eyeball, congenital or not, leading to great enlargement of the eye—hydrophthalmus—the sight is surely destroyed in the end by glaucoma. In such cases, enormous excavations of the optic disk are usually found.

HEMORRHAGIC GLAUCOMA.—The most hopeless form of glaucoma, primary or secondary, is the *hemorrhagic*. The retinal hemorrhages are apt to take place suddenly in the central region and around the optic disk. At first it is difficult to foresee what the ecchymoses indicate, but the increased hardness tells the story. Such hemorrhages, often seemingly without cause, in persons of advanced years, are very apt to be the forerunners of this most pernicious and unmanageable form of glaucoma.

TREATMENT OF GLAUCOMA.—Every glaucomatous eye, when left to itself, terminates in hopeless blindness. The immortal discovery of Von Graefe made an epoch in the history of human sorrow. Till iridectomy was found to be a reasonably certain remedy for the morbid hardness of the globe, but the one sad fate awaited every such case. But we know as little still about the way in which this operation permanently reduces the intra-ocular tension, as we do of the immediate cause of the increased pressure. The success of the treatment, however, in the majority of cases, is not now disputed. Since that forward stride in the therapeutics of this process was made, it has been discovered that eserine and pilocarpine, in addition to their action in contracting the pupil, possess the power of reducing the tension of glaucoma, and, in rare cases, permanently. Usually, however, the action is transient, and in the chronic forms not even temporary relief is afforded; so that we are forced to fall back upon surgical treatment at last. The earlier iridectomy is practised, the greater is the certainty of saving useful sight; hence the immense importance of an early diagnosis. Every surgeon and physician should be able to make the diagnosis promptly, and thus avoid delay. The section, for cosmetic and visual reasons, is generally made upwards, so that the mutilation of the iris shall be covered by the upper lid. An incision, of from 6 to 8 mm., is to be made at the sclero-corneal junction, as near the periphery as possible. This is best done by a Graefe's cataract knife, especially where the chamber is very shallow, as it certainly will be in many cases. The puncture and counter-puncture must be made as in the incision for extraction of cataract, and the point of the knife closely watched as it traverses the chamber, close in front of the iris. If the iris prolapses on completing the section, it may be seized by the fine, toothed forceps, drawn well out, and held steadily till cut off with scissors close to the sclera. Two snips are required, beginning at one end of the incision and finishing at the other, the assistant pulling the iris a little tighter after the first snip. The object is to excise a broad portion of the iris reaching quite to the periphery. Should no prolapsus occur, the closed forceps must be passed carefully into the chamber,

opened well and closed again, thus seizing and slowly drawing out the iris. The previous use of eserine, to contract the pupil as much as possible, facilitates the operation, and diminishes the risk of wounding the lens capsule. After the iris has been properly snipped, the eye should be instantly shut, and gentle compression made, to avoid intra-ocular hemorrhage. After a few minutes let the eye be carefully opened and inspected. If any iris remain imprisoned in either angle of the cut, it must be seized, stretched, and snipped off. If the scleral section is not freed from iris, trouble and doubtful relief are to be expected. Of course, the wire speculum and the fixation forceps are always necessary, and, in most cases, etherization. The same steps and precautions are to be taken as in Graefe's method of extraction, except that the incision into the anterior chamber is shorter. The suspensory ligament and capsule of the lens must not be injured; the eye should be kept lightly bandaged, and the patient quietly in bed, for a few days.

In *acute glaucoma*, this operation, executed properly, and within a few days, shows its greatest triumphs. The longer it is delayed, the greater doubt as to success. In most cases of *chronic, simple glaucoma*, it fails to save useful vision, but the patient should have the only chance. In *chronic, inflammatory glaucoma* it promises better, but often fails to afford permanent benefit to sight. It relieves tension generally, and saves the patient from much suffering in the future, at all events. In both these varieties, it is sometimes necessary to do a second iridectomy, below and opposite the first, to achieve permanent softening of the eye. In *secondary glaucoma*, in addition to removing the cause as far as possible, an iridectomy should always be done, and will often succeed in saving the eye. For *hemorrhagic glaucoma* the operation should never be risked. Immediate extinction of sight from profuse intra-ocular hemorrhage would be almost sure to follow, and, even if it did not, the vision would be lost at last. Of course, in confirmed glaucoma, where no hope of sight can be entertained, the operation should be avoided, except, it may be, to relieve extreme pain. Its execution is then very difficult, and enucleation will at last give the safest and surest relief from suffering. In rare cases of glaucoma simplex, and in other more promising forms, the best executed operation may be followed by rapid and complete loss of sight. While this possibility should be remembered, it should not deter us from a resort to the only hope of relief.

The theory that explains the mechanism of operations for the cure of glaucoma by the filtration cicatrix, has suggested *sclerotomy*. A larger experience with this method must decide on its comparative merits. If any operation is to be performed in hemorrhagic glaucoma, this is the safest and the only one to be recommended. In the chronic and doubtful forms, it may also be tried, as well as in confirmed cases. It certainly removes the peculiar hardness of the globe in some cases, and may, on fair and large trial, replace iridectomy. But the latter has the firmest hold on the confidence of all but a few operators. The object in sclerotomy is to avoid mutilating the iris, and to prevent it from prolapsing into the incision. To avoid this, eserine is freely used before the operation. The first steps are precisely the same as for iridectomy. After counter-puncture, the knife is moved slowly backwards and forwards till the scleral incision is nearly completed. Then it is slowly withdrawn, allowing the aqueous to trickle out very gradually, so that the iris may not be washed into the wound. If it prolapses, the rubber spatula may be used to replace it. Eserine and friction over the cornea, through the medium of the lid, may reduce it. If this cannot be done, it will be better to draw the iris out and snip it off. The eserine treatment may be beneficial in relieving any hardness that sometimes persists after the surgical treatment.

Again I would warn against the unpardonable sin of mistaking glaucoma for cataract, and of using atropine in its treatment.

STRABISMUS.

DEFINITION AND VARIETIES.—Strabismus consists in an inability to fix both eyes on the same point, at the same moment, not due to paralysis. The two eyes move freely together or separately, but one deviates constantly in the same direction and to the same degree. *Convergent* squint, in which one eye turns too far inwards while the other fixes, is the most frequent variety. *Divergent* strabismus, in which the deviation is outwards, is next in frequency. Deflection *upwards* or *downwards*, is of rare occurrence. Strabismus is a deformity, and excludes the benefits of binocular vision. The constant direction and degree of deviation in all possible positions of the eyes, establish the most important diagnostic difference between squint and faulty fixation from paralysis. In the one, the erratic eye, when solicited, turns freely in every direction. In the other, it cannot be budged in the direction of the paralyzed muscle.

Let us assume a convergent squint, in the left eye. Cover the right with a card and compel the faulty eye to act. It will fix and follow the finger wherever normal fixation is possible. But the right eye will now squint behind the card. This forced, secondary deviation will be exactly the same in direction and quantity, as the primary. But simultaneous fixation is nowhere possible. In paralysis, binocular fixation may be easy in all directions but one, and the secondary displacement will be much greater than the primary. In no part of the body are delicate disturbances of muscular equilibrium so quickly detected, and so annoying, as in the rotary muscles of the eyes. The constant double vision cannot be ignored.

Should a given convergence be due to paresis of the external rectus, not only distressing diplopia, but more or less limitation in the outward movements of the eye will be detected. As before, suppose that the left eye converges when both are open. Cut off the right with a card, and the left will follow the finger readily, except when moved to the left. While soliciting movement in this direction, and without avail, notice the right eye behind the card. It will turn in excessively, almost burying itself behind the nose. Both eyes being open, the patient will see double in all points to the left, but single to the right. Instinctively, he learns to avoid the horrible diplopia, by turning the head constantly to the left, thus bringing objects to his right. In deviation from paralysis, there are constant errors of projection and consequent giddiness, except when the faulty eye is closed. If the patient tries to walk with the perfect eye closed, he will stagger. In the case assumed, close the right eye, and holding your finger to the left of the patient, tell him to touch it quickly with his index finger. He will constantly thrust to the left of it.

The degree of strabismus may vary from a mere *cast*, to a deviation of ten mm. or more, constituting a hideous deformity. The linear deviation may be measured with sufficient accuracy, as follows: Shut the non-squinting eye, and request the patient to fix your finger, steadily held about ten inches in front of his nose. Then, with a pen, mark with ink the point of the lower lid that corresponds to the centre of the pupil. This done, open the other eye and tell him to fix the same finger, held in the same position. The eye will now deviate and an ink spot is again made to correspond to the centre of the pupil. The distance between these two ink spots will be, in millimetres, the linear deviation. In the earlier periods of strabismus, when it is often inter-

mittent, there is perhaps always double vision. But by a mental process of abstraction, the patient soon learns to ignore or suppress the image of the crooked eye, and thus gets rid of the horror of diplopia. This process is favored by a variety of circumstances. If the squint begins as early as the first or second year, before the habit of binocular vision is solidly formed, the habit is soon broken up in the interest of single vision. Children learn and unlearn habits far more readily than older persons. Then one eye is often much more imperfect in sight than the other. It is a fact that many children are born with this difference, and that many such become strabismic. In that case, the child squints with the naturally defective eye. The more marked the difference in distinctness of vision between the two eyes, the easier it becomes to fix the attention exclusively on the sharp image, and to ignore the dim one.

In the great majority of cases of confirmed squint, except when it is alternating, the constantly deviating eye will be found defective in sight. The amblyopia is often so great that the patient cannot read even capital letters. The fixing eye will be found better, and generally perfect in sight. It has long been assumed that the defective vision in such cases is due to disuse of the eye—*amblyopia ex anopsia*. While this may be true in part, there is reason to believe that in many cases the defective sight has existed before the deviation, and has played, perhaps, an important part in determining it. According to Schweigger, for one hundred and seventy-seven strabismic patients with one-sided amblyopia, there will be found ninety-eight with a similar visual defect in one eye, without strabismus. Of these ninety-eight patients, forty-seven per cent. will be found hyperopic, showing that hyperopia and amblyopia may exist together, without giving rise, necessarily, to squint. It is quite probable that the long-continued disuse of the squinting eye may increase a natural and pre-existing defect of vision. In consequence of this disparity, binocular vision may never have been learned at all, or but imperfectly, and in case of squint, it is readily unlearned. Strabismus is essentially a disease of childhood or early life, while paralytic affections prevail more among adults, where single vision with two eyes has become a long and imperious habit. A confirmed habit, good or bad, is hard to shake off, however important the interests involved. Hence the diplopia of paralysis is constant and very harassing, and it persists as long as the cause endures. In intra-uterine paralysis or congenital absence of one of the recti muscles, diplopia never occurs. Persons thus affected learn to blend the images where both eyes command the field, and to suppress that of the lagging eye in other directions. I recall the case of a woman, forty years old, whom I treated for *retinitis albuminurica*, from which she recovered with perfect vision in both eyes. I discovered that the right eye could not be rotated outwards at all, and expected to find corresponding diplopia with exaggerated secondary deviation of the left eye. But neither symptom had ever been present. It had always been so, and I found binocular vision in the median line and to the left, and monocular single vision to the right. In looking at objects to the right, she used the left eye and suppressed the image of the right. I have recently examined a young man whose eyes present a similar condition of affairs.

CAUSES OF STRABISMUS.—Till the time of Donders, the etiology of squint was a matter of vague conjecture. The most absurd explanations were often detailed with great assurance, and still are, even by some physicians. Donders demonstrated that in two-thirds of the cases of convergent squint, there was hyperopia, an anomaly of refraction imposing constant strain of accommodation. The constantly associated actions of convergence and accommodation, and the possibility of exaggerating either by emphasizing the other, were so fully

elucidated by him, that little positive knowledge has since been added. His theory, based on the physical fact of hyperopia, was that the excessive convergence of one eye enabled the other to focus successfully for close work, in spite of the hyperopia. The theory demands that *all* hyperopes should become cross-eyed, and in proportion to their degree of hyperopia. But this does not prove true in fact. As a rule, the degree of hyperopia in convergent squint, is not excessive. Some patients with extreme degrees of hyperopia squint, and some do not, but hold the book very close, as if myopic. There are many persons with hyperopia in varying degrees, and often with congenital defect of sight in one eye, who never squint. Again, some emmetropes are victims of strabismus, both convergent and divergent. Even hyperopes are found affected with divergent strabismus, and myopes with convergent. Hence there must be some other cause, besides an anomaly of refraction, which determines it in one case and not in another. What can this be, and where can it attach, except to the *muscles* themselves? In many cases, marked insufficiency of one rectus muscle exists, and yet no manifest strabismus ever develops in its antagonist. The impulse to, and predominating interests of, binocular vision, dominate the want of balance, and keep the eyes straight. But exclude one eye from the visual act, and the disturbed muscular equilibrium will show itself at once. Direct the eyes to be fixed on the point of a pencil, at eight or ten inches, and then slip a card in front of one eye. The excluded eye will swing inwards or outwards, and twitch quickly back into position when the card is removed. As a rule, the preponderance falls on the side of the internus in childhood, and of the externus in later years.

Such cases of insufficiency are sometimes called latent squint, but improperly. So it seems that disturbance of the natural muscular balance alone, is not enough to determine strabismus, especially when the vision is perfect in both eyes. Again in adults, associated with hyperopia we often find insufficiency of the interni, but without strabismus. Such patients complain of pain and fatigue on close application of the eyes, and often shut and press on them for relief. This is muscular asthenopia, aggravated by hyperopia, and yet with no manifest squint. Binocularly, they fix and see single, but exclude one eye, and it deviates outwards. Direct such a patient to fix both eyes on a pencil, constantly approaching the nose. At six inches or perhaps nearer, one eye will swing outwards and the pencil appear double, with crossed images. Tried by other tests the same insufficiency of the internus will show itself, and yet the patient does not squint. Physiologically, the relative power of the two muscles is largely in favor of the internus. In ordinary avocations, the interni are in almost constant use, converging the eyes for finite distances. The external, at most are only called on to reduce the eyes from convergence to parallelism. Hence the far greater strength of the internal recti muscles. A glass prism before one eye, with its refracting angle towards the nose, produces double vision by deflecting the image towards its base. Single vision can only be restored by an extra action of the internal rectus, converging the eye behind the prism. If the prism be reversed, diplopia will again ensue, and the external rectus is called on to relieve it. The strongest prism that either muscle can thus overcome, in the interest of single vision, will be a reasonable measure of its strength. It is much easier to overcome strong prisms at ten or twelve inches, than at twenty feet. Ulrich suggests that it is well to test the eyes for an object at twenty-five centimetres (about ten inches), and at six metres (nearly twenty feet). In emmetropes, a No. six or seven prism can be neutralized by the externus, but one very much stronger by the internus. Ulrich gives the average normal power of the converging muscles at forty-five, and assumes pathological weakness when they cease to neutralize a prism of twenty-five to thirty. Starting from these premises to

investigate the relative muscular strength in hyperopes, where convergent strabismus does not exist, Ulrich concludes that all patients with hyperopia, who do not squint, have insufficiency of the internal recti muscles.

This original difference in muscular balance would seem to account for the fact that a blind eye, in course of time, will sometimes converge, at others diverge, and at others remain straight. The same explanation applies to the occasional occurrence of either convergent or divergent squint in emmetropes. Even hyperopes sometimes become victims of divergent strabismus. I am treating a young man who, when he came to me, had a divergence of ten mm., and who habitually fixed with the right eye, for all distances. In that eye he was myopic three dioptries (twelve inches). Of course his vision for distance was very imperfect, and he had never worn glasses. With a correcting concave glass, the remote vision was perfect. To my surprise, when the right eye was covered, and the divergent, left eye brought to bear, his distant sight was found perfect, and the eye emmetropic. Yet he constantly fixed with the right eye and suppressed the image of the left, seeing very poorly at a distance, and reading well and exclusively with the myopic right eye. I have frequently seen patients with one near-sighted and one long-range eye. But they fix distant objects with the one and read with the other. How shall we account for the remarkable exception presented in this case? I can explain it by supposing that, when the strabismus developed ten years ago, both eyes were emmetropic and equal in vision. But the patient learned to fix constantly with the right eye, and to suppress the image of the left. At last myopia developed in the eye constantly used, and the old habit of exclusively fixing with it persisted. He remembers that distant vision has become very much impaired in the last three years. I have divided in succession both external recti, and have thus greatly reduced the degree of divergence. Since the last operation he has learned to fix distant objects with the left eye, while he still reads with the right, having gained very greatly in range of vision. By an advancement of the internal rectus of one eye, I expect to correct the remaining divergence.

A long experience has taught me that insufficiency of the interni is one of the most troublesome complications in non-squinting hyperopes. In them we have to combat muscular and accommodative asthenopia at the same time.

Etiology of Divergent Strabismus.—In the great majority of cases, divergence of the eyes is seen in myopic subjects. In these, the increased size of the globe antero-posteriorly, is caused by bulging of the back part of the eye. The direction of this staphyloma posticum is such as to favor the power of the externi. Such persons have little use for their accommodation. Hence convergence is not dominated by the focusing impulse, as in other forms of refraction. Myopes of high degree must bring objects very near in order to see them sharply. The resulting, painful degree of convergence, unaided by impulses of accommodation, cannot be maintained for protracted, close work. Soon one or the other eye turns outwards, and monocular vision is adopted. The amount of myopia, as well as the acuity of vision, often differs in the two eyes, making prolonged binocular fixation still more difficult. The most myopic and defective soon yields to the pressing tendency, and diverges. But here again some other factor, besides the state of refraction, is required to explain the occasional presence of myopia without divergent, or even with convergent, strabismus. The original, relative length and strength of the externus and of the internus, have something to do in bringing about strabismus. The chapter on the etiology of strabismus, in all its details, is not yet written.

TREATMENT OF STRABISMUS.—It is well to remember that some cases of squint recover spontaneously. In my observation, however, such cases are very rare.

The few recoveries that I have seen, have been only partial, some appreciable deviation being still detected. It is chiefly in convergent strabismus that these favorable changes take place, with the progress of years and the disappearance of active accommodation, and though I cannot agree with De Wecker, who asserts that the majority of cases of convergent strabismus get well spontaneously, if let alone, still, the dominating influence of accommodation over convergence in early years, and its subsidence in advanced years, should not be forgotten. In intermittent squint, beginning in childhood, and being the first stage, often, of fixed deformity, it is sometimes possible to effect a cure without operation. The cross is only noticed when the child looks closely at small objects, or is embarrassed, or perhaps deranged in health. Appearing more and more frequently, at length permanent contraction of the prevailing muscle is the result. This variety is frequent in hyperopic children, and shows itself about the time they are put to school. If the sight is equal and perfect in each eye, the prospect of cure by hygienic and medical treatment is greatly enhanced. But equality or perfection of sight, at this early age, before the child knows its letters, is very difficult to determine. Still, an effort at cure should be attempted. The well-known influence of spasm of the ciliary muscle in exaggerating convergence, should be neutralized. This is best done by instillations of atropia. One or two drops of a one-grain solution, may be safely dropped into the eyes of the child twice a day. Often little or no tendency to squint will show itself while this treatment is kept up, and by perseverance for weeks or months a permanent cure may be brought about. Homatropine in stronger solution (four grains to the ounce) can be used in the same way, and is less likely to produce constitutional disturbance. Eserine has likewise been tried for the same object. Its action is to stimulate the accommodation, and thus enable the eyes to overcome the hyperopia without excessive convergence. But in children under five years, in which this treatment promises best, one cannot risk the constant use of convex glasses to neutralize the hyperopia while the atropine treatment is carried out, and afterwards. Strabismus that can be controlled by atropine or by glasses, or both, if operated on, will probably show divergent eyes in after years. All close use of the eyes for study must be interdicted, and the use of tonics, aided by fresh air and good regular diet, enforced. Goggles and other devices cannot correct the squint, but may be of use in compelling separate exercise of the eyes.

Training with the stereoscope, as recommended by Javal, involves a degree of intelligence and attention not possible in children. Confirmed strabismus, not controlled at all by atropine and convex glasses, demands surgical interference, and the earlier it is resorted to the better the success. There is no deformity where a timely and skilful operation is so certainly successful. In the few cases in which tenotomy produces little or no effect, a proper advancement of the antagonist muscle secures the end desired. These two operations may often be happily combined. But great circumspection, skill, and patience, are required to secure an abiding, good result. The zeal of inexperienced operators to obtain an immediate and complete correction, often leads them to do a double tenotomy at once. This may be very gratifying to the parents or friends, and secure a cheerful honorarium, and yet may be a curse to the patient in the ultimate course of life. Insufficiency of the severed muscles, and unsightly divergence in after years, may drive the patient to wish that his benefactor, now perhaps happily dead, had never lived! Such a deformity is far greater and more difficult to remedy than the original squint. A rightly proportioned and skilfully executed advancement, however, may triumph even over these unfortunate excesses. What operator of long experience has not had these dilemmas with divergent horns, come back on him in the winter of his discontent? Perhaps more of them fall into other hands. Thoughtful operators proceed with

great prudence, preferring too little immediate effect to excessive remote results. A slight remaining convergence attracts little notice, and may disappear with age, as presbyopia develops. The aim should be to attain the best possible correction, with the least insufficiency and disturbance in the binocular movements. Then again, a desire to correct an extreme degree of convergence by operating only on the *crooked* eye, making the dissection very extensive, or repeating the operation on the same eye, is often disastrous. Marked insufficiency of the weakened muscle, undue prominence of the eye, sinking in of the caruncle, and great disparity between the eyes, will result. Besides, if the operator has not taken the precaution to detect and demonstrate to the parents the already defective sight in the faulty eye, he will get the additional credit of having destroyed the sight by his operations! Slight degrees of squint may indeed be relieved by one judicious operation. But in the great majority of cases of higher degrees, it is far better to operate on both eyes, at intervals. In very extreme cases, however, a simultaneous, double tenotomy may be safely done, and it is sometimes the only way to get sufficient correction.

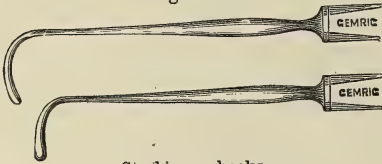
As a rule, it is wiser to operate first on the worse eye, and then wait a few days or weeks for the definitive result, before attacking the other. In all serious undertakings, "make haste slowly" is a safe injunction. Of course this does not suit the *itinerant operator*, but I am speaking of honest and conscientious men. The object to be secured is the detachment of the tendon from its scleral insertion, so that it may retract and readhere farther back. We want to weaken, but not to destroy its rotating influence. The second insertion must be within the capsule of Tenon, else the result will be excessive. But the immediate effect of a skilful tenotomy will vary in different cases. When the eyes are deep-seated and small, a much bolder operation may be risked than where the contrary obtains. In the former case, some degree of exophthalmus, especially if equally divided between the two eyes, is desirable. Then again, the blendings of the tendon with the capsule of Tenon, as it passes through, vary in extent and rigidity. The same is true of the tendinous attachment to the sclera. Moreover, the amount of correction depends more on the active energy of the antagonist than upon the retraction of the severed muscle. A greatly stretched and weakened antagonist is not likely to assert itself and produce a marked immediate effect. We must not only measure, as exactly as may be, the linear deviation, but the extent of possible movement inwards and outwards. In convergence, the possible rotations inwards are excessive, and the outward rotations somewhat limited. In divergence the contrary obtains. By requesting the patient to fix your finger with both eyes open, and moving it far to one side and then to the other, you test the extent of rotation in these opposite directions. The margin of the cornea and the outer commissure of the lids are the external land-marks. The inner margin of the cornea, as compared with the lower punctum, will be the guide for inward movements. Sometimes the centre of the cornea can be drawn so far beyond the punctum, that it is nearly buried out of sight. In such a case, with a weak external rectus and marked limitation in the outward rotations, one can scarcely get too much effect from the tenotomy. Indeed, it may be necessary to combine with it, advancement of the externus. We want to diminish the excessive motion in one direction, and increase it in the other, so as to restore a natural equilibrium. The nice point is to insure the needed correction with the least muscular insufficiency. If you correct the position completely, with marked muscular insufficiency, an opposite deformity in after years is almost certain. The limitations of the weakened muscle must be tested as soon as possible after the tenotomy.

If the patient has been put under the effect of ether, time must be given for this to pass off. This sometimes causes embarrassing delay. If the extreme

possible rotation, noted before, has been positively reduced, the muscle has been completely severed. Otherwise, perhaps not, and the wound must be explored further, and the eye then tested again. As a rule, I desire to see enough power left in the internus to bring the edge of the cornea to, or even a trifle beyond, the punctum. Should the movement inwards be more limited, the judicious use of a suture will be required, but in most cases this will not be needed.

The instruments necessary for this operation are a stop-speculum (Fig. 921), a pair of toothed forceps for picking up the conjunctiva, two strabismus hooks, a large and a small (Fig. 935), and blunt but very sharp scissors (Fig. 936). The scissors may be straight, or bent on the edge. I prefer them

Fig. 935.



Strabismus hooks.

Fig. 936.



Strabismus scissors.

straight. A very soft, clean sponge is likewise to be provided. Then comes the question of ether. For a great many years, I have very rarely used chloroform, and only when there was peculiar trouble in securing complete anæsthesia. Ether must be pushed rapidly, and the air excluded, else thorough insensibility cannot be produced. This is the only way to secure the needed quiet, at the least risk to life; and if the first moment of sudden unconsciousness be seized for the operation, the patient need not take much ether, nor be kept long under its influence. In all cases in adults, I urge that anæsthesia be not employed. The operation is quickly over, not very painful, and free from danger, and we can then at once test the effect secured by the tenotomy. With timid people, who have no self-control or confidence, and with children, we cannot do without an anæsthetic.

The patient should lie on his back, on a lounge or operating chair, with the head thrown slightly backwards. When the stop-speculum is adjusted, the first steps of the operation are facilitated by forced rotation of the eye directly outwards. This is effected by an assistant, who fixes the eye near the outer margin of the cornea, in the horizontal meridian. Great care must be taken not to rotate the globe on its antero-posterior diameter, else the relation of the incision to the tendon will be altered. I generally employ the subconjunctival operation. The conjunctiva is seized with the small toothed forceps, about three or four mm. from the inner edge of the cornea, and as nearly as possible over the lower edge of the expanded tendon to be detached; and it is then divided with the scissors, horizontally backwards, far enough to afford room for the further steps of the operation. It is next detached by a few movements of the points of the scissors over the seat of the tendon. Then letting go the conjunctiva, the capsule of Tenon is seized through the conjunctival opening, the forceps being pressed with a little firmness on the sclera, and is opened and detached to the same extent. The forceps still holding and raising the detached conjunctiva and capsule, the large hook is next passed in, pushed backwards, and the point swept from below upwards under the tendon, being pressed firmly on the sclera in this movement. This is the most difficult and important manœuvre, next to detaching the tendon, and its successful execution greatly simplifies the rest of the procedure. The firm resistance felt, when the expanded tendon is thus gathered in the concavity of the hook, is the assurance that it has been secured.

Drawing the hook forwards till it is arrested by the tendon at its insertion, it is held firmly, and the tendon is then divided by a few snips of the scissors from below upwards, subconjunctivally. Then the same or the smaller hook may be swept upwards, to be sure that no fibres of the tendon above have escaped; and likewise downwards. If, when this is fairly done, the hook comes forwards under the conjunctiva, close to the cornea, meeting no resistance, it is sure that the tendon is entirely detached. By loosening it between the hook and the sclera, and as close to the latter as possible, there is no serious sacrifice of the tendon.

If ether has not been used, the effect can be tested after a few seconds of closure of the lids by pressure with an iced sponge. If no marked limitation of rotation in the direction of the contracted muscle is perceptible, some shreds of tendon have escaped, above, below, or farther back between the tendinous substance and the sclera. The wound must then again be explored carefully in these directions, and such filaments, if found, divided. To do this the speculum may be reintroduced, or the eye may be held open by the fingers of an assistant. After this, another test of limitation may be applied. If ether has been used, it will be necessary to wait five or ten minutes till consciousness and self-control are regained. For reasons already given, the immediate effect varies in different cases, but if a limitation of from three to four mm. has not been obtained, it is because the tendon has not been completely separated. As a guide in reaching for the tendon with the blunt hook, it should be remembered that the centre of insertion of the internus is about five and a half mm. from the margin of the cornea, and that the corresponding point of the externus is slightly more distant.

The same steps are to be taken in operating on the external rectus, remembering, however, that a complete tenotomy in this instance does not accomplish as much as in the former case. Tenotomy of the superior and inferior recti is rarely executed, but is done in the same way. The hemorrhage is usually very slight, and the blood is soon absorbed from beneath the conjunctiva. Quick removal of the speculum and pressure with a cold sponge readily check it. The vision of a previously amblyopic eye is sometimes immediately much improved. In a little blonde child, six years old, with excessive convergence, in whose case I practised a double tenotomy, the defective eye, from being able to recognize no letter at fifteen feet, improved so that its vision was 0.2, as soon as tested. But the improvement, if it continues at all afterwards, is then much less rapid.

I must again exhort the surgeon not to be too impatient to accomplish complete correction by the first tenotomy, whether single or double. Wait patiently a few weeks or months, enjoining frequent exercise of the weak muscles, and using atropine, glasses, stereoscope, separate exercise of the amblyopic eye, etc., before risking a second operation. This plan is especially to be employed if the squint be convergent, and the remaining deviation slight. If diplopia occurs, it is an encouraging symptom, and may give way to binocular vision; or it may again subside by suppression.

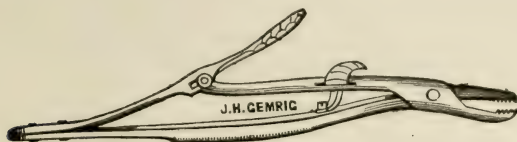
In testing the effect produced by a tenotomy of the externus, we must be guided by the outer edge of the cornea and the external commissure of the lids. Before a successful operation, the corneal margin can be rotated beyond the commissure, while now it falls short by two or three mm. The correcting effect of division of the externus is much less than that of the same operation on the internus. In either case it is wise to be satisfied with slight insufficiency, and not to make extensive dissections or incisions in the capsule. After tenotomy, especially of the internus, there is some increased prominence of the globe. This is one of the numerous reasons for operating on both eyes, rather than attempting to accomplish the whole correction on one side. The greater

or less effect produced by a perfect tenotomy depends more on the activity of the antagonist, and its subsequent shortening, than on the elongation of the divided muscle. Hence, in cases of contraction from paralysis of the antagonist, or from a previous and excessive operation, tenotomy has no effect except to increase the already unsightly exophthalmus. A well-timed and extended *advancement* is the only rational interference in such cases. While tenotomy sets the tendon back, and weakens its effect, advancement sets it forwards and increases its action. Tenotomy produces exophthalmus; advancement helps to diminish it. Tenotomy is always practised on the too much contracted muscle, while advancement is employed for that which is elongated and weakened, on purpose to shorten it and increase its power. Advancement seems a more rational way of restoring equilibrium between muscles than tenotomy. But, owing mainly to the difficulty in its execution, it is not often resorted to, except to correct over-effects or deviation from paralysis. In most, if not in all cases, however, of so-called latent strabismus, or insufficiency, advancement promises more certain relief than tenotomy. Theoretically, the new insertion may not be symmetrical with the original attachment, and may result in diplopia and other binocular inconveniences. But this has not been realized in practice. Whether the advanced tendon has been spread a little more or less, or whether the upper edge has been advanced a little more than the lower, seems not to exercise any serious influence on the future use of the eyes. Even in extreme cases of insufficiency from excessive tenotomy, and in those of rigid contraction from paralysis, it is astonishing how much may be gained by this operation. I have advanced totally inactive muscles left by excessive strabismus operations, twenty years before, with very great improvement in appearance, and with reasonable restoration of motor activity. It seems that complete severance of a tendon from all connection with the globe, even for long years, does not lead to atrophy and uselessness of the muscle. When reunited, in a favorable position, it soon discharges its functions well. My own advancements, and many others which I have seen, have given very gratifying results. Indications for this operation will certainly increase with further experience. The little more time and trouble required for executing a successful advancement, should not weigh against the best interests of the patient and of enlightened surgery.

The operation is performed as follows: The patient having been rendered thoroughly unconscious with ether, and the eye being held open by a speculum, as in strabotomy, the ball is seized by strong fixation forceps near the margin of the cornea, directly opposite the muscle to be advanced. It is then firmly rotated in that direction, so as to expose the region to be dissected. Held thus by an aid, the surgeon seizes a fold of conjunctiva, about two mm. from the corneal margin, and divides it vertically for five or six mm., and with repeated touches separates it from the sclera over the muscular insertion, and farther back. When the tendinous attachment is found, the blunt hook is passed under the tendon, so as to raise it and make it tense. Holding it thus firmly, one blade of a toothed forceps is passed behind and one in front of it, so as to seize and hold it tightly. Then with the scissors, it is detached close to the sclera and held and lifted forwards, so that it may be pierced with the needle from behind forwards. A well-waxed thread eighteen inches or two feet long is sufficient. This is armed with a needle placed in the middle, and with another needle near each end. The main needle, fixed with Sands's holder (Fig. 937), is then passed through the middle of the raised and stretched tendon, from behind, and about four mm. from the forceps. The needle may be passed forwards under the conjunctiva, finally piercing it near the cut edge. The holder removed, the needle is seized and drawn through five or six inches. Then one of the other needles is fixed and care-

fully passed under the conjunctiva next the cornea, avoiding piercing the sclera, and brought out about three mm. from the centre of the upper margin of the cornea; the thread is drawn through, and the needle is removed. Then the other is secured and passed in the same way below. These needles

Fig. 937.



Sands's needle-holder.

being removed, and the threads cut off close to the first needle, the surgeon is ready to tie the knots. The tendon is now held by two threads, which are to be tied, one by the operator, and the other by his assistant. They must be gently and evenly tightened, and firmly knotted. Before tying the threads, it is better to remove the speculum. In this way the tendon is drawn firmly forwards and spread out over the denuded sclera. If the antagonist muscle is much contracted, its tendon should be divided, after the threads are placed and before tying them. In this way the effect may be greatly increased. Then the amount of advancement may be intensified by piercing the tendon farther back towards the caruncle, for the internus, and towards the equator for the externus. In very high deviations, a piece of the tendon may be sacrificed before knotting the threads.

In the extreme cases to which this thread operation has been usually restricted, it is desirable to adopt every means of increasing the effect, and even then a second advancement may be necessary. In one of the worst cases which I have ever seen, produced by tenotomy of the internus twenty years before, a second advancement was made a year after the first, and the result was admirable.

The operation having been completed, the patient should be put quietly to bed, with the eyes bandaged, and cold water dressings should be used for a few hours. The next day the eye may be gently opened, but not allowed to move much, and then closed. At the end of forty-eight hours of quiet, the threads may be carefully removed, but the eyes must be immediately rebandaged, and kept so for several days longer till the adhesions are firm. The success of this very important operation depends largely upon the absolute stillness of the eyes for the first four days. As the method of advancement is more perfected and made easier, its application will become more general. In moderate cases of strabismus, and in all cases of insufficiency requiring surgical treatment, the muscular balance may be restored by advancing the elongated muscle instead of setting back the contracted one. The dangers of muscular insufficiency, sinking of the caruncle, and unsightly exophthalmus, will be thus entirely avoided. The only instruments needed in this operation more than in an ordinary strabotomy, are the three needles. A double hook, as devised by De Wecker, facilitates the operation, but is not indispensable. I recently made a thread advancement of the externus in a young medical student. He first had very troublesome insufficiency of the interni, for the relief of which I employed division of the externi, first of one, and, a few days after, of the other. Relief was only partial, and the externi were divided a second time. Then convergence with distressing diplopia followed. All objects beyond eight inches were doubled, with homonymous images, and anything held nearer than four inches was seen double, with crossed images. I

then made a careful advancement of one externus, with complete relief. In such a case again, I would advance the internus in the first place.

There are but few accidents possible after a strabotomy. There may, in rare cases, be profuse hemorrhage, which is easily controlled by cold compresses, and which does not interfere with the result. Very rarely, endocapsulitis with some suppuration occurs. With blunt scissors, used with ordinary care, there is no danger of cutting through the sclera. A few times I have seen pretty severe inflammation, and marginal ulceration of the cornea, follow an advancement, but they were always controllable, and resulted in no damage to sight.

DISEASES OF THE EYELIDS.

BLEPHARITIS.—Inflammation of any part of the eyelid is called blepharitis. Having regard to the texture first and chiefly involved, it is called blepharitis ciliaris, blepharitis marginalis, or simply blepharitis. All serious inflammation of the conjunctiva is attended by more or less blepharitis. Erysipelas of the face is apt to invade the lids, as elsewhere described. Abscesses of these parts, their importance and special treatment, have been considered in connection with injuries of the orbit. The worst cases of ectropium follow deep and extensive burns of the lids, or sloughing from erysipelas. A reserved prognosis in such cases is always wise. The common styne is often attended by great pain and alarming swelling, but is easily diagnosed by a point of greatest tenderness to pressure. It discharges spontaneously or by puncture, like a furuncle, and soon recovers. A succession of styes and boils indicates bad assimilation, and is best treated by constitutional tonics. If a costive habit be present, it must be relieved by laxatives. Locally, continued warm poulticing is all that is required. Syphilitic and caneroid ulcerations of the eyelids are always alarming. They readily lead to destruction of tissue, exposure of the eye, ectropium, painful loss of sight, and even loss of life. Epithelioma and other destructive processes in the upper lid are vastly more disastrous than in the lower. While the entire lower lid may be destroyed, or removed by operation, without serious deformity or danger to the integrity of the eye, a very small defect in the upper lid both excites remark and becomes grave in its consequences. Epithelioma of the eyelids requires prompt and radical operative treatment. It is in these cases especially, that the melancholy effects of the caustic applications, so much in vogue among mercenary quacks, are witnessed. As soon as a syphilitic sore is detected on the eyelids, antisiphilitic treatment must be heroically adopted, and no operation resorted to, except perhaps at a later period, for plastic purposes.

The most common form of inflammation is that which is limited to the free edges of the lids, and is called *blepharitis marginalis*, or *ciliaris*. It is confined mainly to scrofulous children, seldom occurring for the first time in adults, except as a complication of dacryocystitis. The exclusive victims of this disease, strumous children, are likely to have also phlyctenular keratitis, with eczematous eruptions on the face and scalp, behind the ears, and in and around the nose, and enlargement of the glands of the neck. The children of indigent and dissipated parents of dirty habits, are the most frequent sufferers, and their successful treatment is almost impossible.

The *diagnosis* of this disease is very simple. The redness and swelling of the margins of the lids are not striking, and often very partial. But more or less scabbing in the region of the eyelashes is a constant phenomenon. Suppuration in the individual hair follicles, and the formation of crusts by drying, that unite the lashes in tufts and sometimes accumulate for months,

becoming large and almost horny, are the characteristic symptoms. These scabs adhere very closely, and are hard to remove. When they are fully detached, the lid bleeds from ulceration of the skin, a process that may be limited to a few cilia, or may extend the entire length of the lid. The scabbing, burrowing of pus, and destruction of the hair bulbs, continue for years, till the patient is at last deprived of eyelashes, seriously disfigured, and annoyed for life.

Treatment.—Absolute cleanliness must be enforced. The lids are to be bathed with warm water, for half an hour or longer, twice a day. When the scabs are thus softened, they must be thoroughly removed by rubbing with a soft rag over the end of the finger. This failing, they must be detached by a small spatula, or with cilia forceps, no matter at what cost of screaming and bleeding. Firmness on the part of the surgeon is demanded, as the nurse is always timid and fails to do the work fully. The child must be held across the nurse's lap, face upwards, and the head firmly clasped by the surgeon's knees. He is thus master of the situation if he have already mastered the mother or nurse. When every trace of the scabs has been removed, it greatly expedites the cure to trim the lashes as closely as possible with a small pair of scissors, and to repeat this at least once a week. The raw surfaces, thus exposed and dried, are now to be touched quickly and lightly with a pointed stick of nitrate of silver. A solution of from ten to twenty grains may be used in preference, applied carefully with a small brush, and limited strictly to the ulcerated portion. Great care must be exercised to prevent its flowing into the eye. When the surface is slightly whitened, the free use of water will remove the surplus. This may be repeated once or twice a week, as long as there is any manifest ulceration. In the evening, before bedtime, warm ablutions, cleansing, and drying, must be followed by the use of some one of the mercurial salves, rubbed along the roots of the lashes and left till morning. These should be weak, non-irritating, and in small quantity, but well rubbed in with the finger. Calomel, with vaseline or lard, gr. j to 3j, or red precipitate, gr. ss to 3j, pure and thoroughly incorporated by rubbing, are excellent remedies. The yellow oxide of mercury in the same strength may also be applied, but I find that it often causes too much irritation. For many years I have used the diluted, brown citrine ointment with almost constant success. On the lids I use 3j of the ointment, rubbed up with 3iij of lard. For the nose, ears, scalp, lips, etc., it may be applied in full strength. After thorough washing with soap and warm water, to remove all the dry scabs, the raw surface should be brushed with the solution of silver nitrate, and afterwards well greased with the salve. This is best done at night, and the eyelids may be treated in the same way.¹ If, after a fair trial, one of these salves fails, another may be tried. After a few days of such treatment, the scabs will cease to form, and the force of the malady will be greatly lessened. But the use of the salve must be kept up for months, at longer intervals, in order to prevent a return of the diseased process.

At first the lids must be freed and greased every night. Then every second night, afterwards twice a week, and, finally, at least one application of the salve every week must be continued for months after the lids seem well. Till the cure is well advanced, the surgeon himself should conduct the treatment, even applying the salve in the day himself, if he cannot be sure of its proper use at night. Combined with these necessary, local measures, the long-

¹ The citrine ointment may be made according to the following formula: R.—Hydrargyri, ʒjss; Acid. nitrici, ʒijss; Olei morrhue, ʒxvjss. Dissolve the mercury in the acid; then heat the oil in an earthen vessel, and, when the temperature reaches 200° F., remove it from the fire. To this add the mercurial solution, and, with a wooden spatula, stir constantly as long as effervescence continues, and afterwards occasionally until the ointment stiffens.

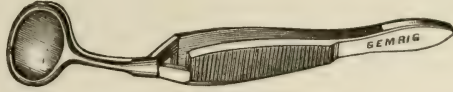
continued use of iron, iodine, and cod-liver oil, inwardly, must be enforced. A favorite remedy with me, is the syrup of iodide of iron, long continued. As a dose after each meal, I give as many drops as the child is years old. Bathing the child at least twice a week, at bedtime, in tepid water, followed by lively friction; good nutritious food at regular intervals; healthy hygienic surroundings; and free, daily exercise in the open air, with proper attention to clothing and cleanliness, must be enforced as a religious duty. I cannot too strongly emphasize the necessity for long perseverance in invigorating general treatment, in this class of patients. Present relief and improved health for life, will be thus gained. Unsightly loss of the eyelashes, blear-eyes, trichiasis, ectropium, weeping, and a train of other torments, are prevented by proper, early treatment. The management of phlyctenular keratitis, and of the skin-diseases so often associated with blepharitis ciliaris, has been described under another head. I wish only to call special attention here to the prompt relief afforded by the mechanical removal of the thickened epithelium at the seat of the phlyctenula, and along the bands of vessels leading to it, in the so-called "band keratitis." I am constantly in the habit of using a wooden tooth-pick, and prefer it to the spud or probe. The tooth-pick must be hard, tough, and sufficiently stiff. The small end is dipped in pure carbolic acid, and then ploughed along the course of the vessels and the seat of the phlyctenula, so as to scratch off the half-dead tissues. This must be done thoroughly, holding the lids firmly apart with the thumb and finger, without eversion. The bloodvessels are thus scraped off with the other new products, and the free bleeding is decidedly beneficial. The point of the tooth-pick can now and then be dipped in the acid, so as to whiten and destroy the diseased tissues. Water can be held ready, and put on if too much acid is present. The wood absorbs and holds the solution better than a metal instrument. After this is thoroughly done, a drop or two of atropine solution relieves the pain. It is wonderful how quickly the violent symptoms are thus controlled.

CHALAZION.—Inflammation with obstruction of the excretory ducts of the Meibomian glands of the lids, is a rather common trouble. Some swelling, like that of a sty, soreness, and pain, are present, and in a short time a yellow point indicates a collection of pus and of the proper secretion of the follicle. Warm fomentations at first, and puncture when the ripe stage appears, are the successful remedies. In adults, tumors of the lids often develop with little or no inflammation, projecting under the skin and giving the feeling to the finger of a hard shot or bullet. These are sometimes single, but oftener multiple, and a succession of them is frequently noticed. They are situated over the region of the tarsus of the upper or lower lid, and sometimes reach the size of a hazel-nut, mechanically impeding the free movements of the lids. They are situated in the thickness of the tarsal cartilage, and are composed of a cyst, filled with a tough, gelatinous substance. Now and then, with more acute inflammation, the contents are somewhat purulent. This tumor is generally called *chalazion*, and requires surgical treatment. One method is to evert the lid, find the thinned point, and puncture through the conjunctiva. The incision is usually made perpendicularly to the free edge of the lid, and the contents are scooped out. If the cyst be rudely torn in this process, in various directions, complete obliteration from adhesive inflammation will be more certainly secured. If the everted lid be firmly squeezed between the thumb and finger-nail, the contents and cyst wall will be more surely forced out. If this be thoroughly done, no cauterization of the sac will be needed.

Where the cyst-wall is thick and hard, and the growth presents itself conspicuously under the skin, I much prefer enucleation. This is done through

the skin, and with the aid of the ring forceps (Fig. 938), to avoid bleeding. When the blades have been firmly closed by tightening the screw, and the tumor has been made to project sharply through the ring, the skin is incised over the whole length of the growth, longitudinally. A few drops

Fig. 938.



Ring-forceps for tumors of eyelid.

of blood escape on cutting through the skin, but, this being sponged away, no further trouble from hemorrhage is experienced. The cyst is now exposed, and with a few snips of scissors carefully detached from the other tissues, excepting underneath. An assistant then draws the skin aside with forceps, when the cyst is seized, raised from its bed, and detached from the parts below. Care should always be taken to remove as little of the surrounding structures of the lid as possible, and to avoid cutting a hole through the conjunctiva. A small opening in the conjunctiva does no harm, but it should be left entire, if possible. When the cyst and its contents are removed, the wound is closed with one or at most two stitches in the skin. It heals by first intention, and all traces are gone in a few days. This little operation, when neatly done, is very satisfactory; but when awkwardly executed, insufficiency of the lid, notching of its margin, and sad deformity may result. There is no use in cauterizing these tumors, or rubbing them with salves, or taking constitutional remedies to remove them. Such measures do not succeed, worry the patient, and must yield at last to proper surgical treatment. Tonics, especially iron and bitter remedies, may be useful in promoting a better assimilation, and preventing the occurrence of new growths.

SEBACEOUS TUMORS, either congenital or acquired, sometimes form under the skin, about the edge of the orbit. They may reach a large size, and sometimes contain hairs. Where such a growth presses upon the bone, it develops a pit, and is usually firmly adherent to the periosteum, making complete removal difficult. Rules for the direction of incisions for their removal, and other precautions, have already been given. They usually bleed freely, and, when the cyst is cut, as it is apt to be, the operation may become very troublesome. If any portion of the sac is left, the tumor is sure to be reproduced. After adequate stitching, a compress is put over the pit that is left behind, and a roller is applied to prevent hemorrhage and subsequent supuration.

LAGOPHTHALMUS.—The name *lagophthalmus*, or *hare's-eye*, is based on a romantic notion that the timid animal after which it is called sleeps with its eyes open. Lagophthalmus is generally due to paralysis of the facial nerve and the muscles which it supplies, but sometimes results from cicatrices of various kinds and degrees, and rarely from congenital defects. Great distress and serious danger to the integrity of the eye always result from paralysis of the orbicularis muscle. Constant weeping during wakeful hours, and dryness from exposure in sleep, keep the eye always irritable, and ready to take on destructive inflammation. The necessity for the constant, healthy action of the sphincter of the eyelids and of Horner's muscle, shows itself in defective function of the sewer system of the eye. *Epiphora*, or overflow

of tears, is the first symptom of this great trouble, and persists as long as any deficiency of muscular activity continues. Whether facial paralysis be due to peripheric or central causes, or to disease of the drum of the ear, it may never disappear, in which event surgical relief is the only hope. The lids, in every case, should, during sleep, be kept closed by a compress and bandage, to prevent the evils of exposure. Even by day, an hour's rest with the eye thus closed by a wet compress, affords great comfort and protection. When inflammation and ulceration of the cornea set in, constant protection by closing the lids must be enforced. More permanent comfort may be secured by a plastic operation on the lids. This is done by paring the free edges of the upper and lower lids, near the outer commissure, and uniting them by stitches or twisted sutures. By leaving the outer angle itself free, the union can be afterwards severed, in case the paralysis disappears. The edges should be made raw for from a fourth to half an inch, according to the amount of insufficiency. Nothing need be cut away but the skin covering the free margins, avoiding the Meibomian follicles and the eyelashes. The union thus secured, relieves the patient's distress, and greatly improves his personal appearance. In confirmed cases, resulting from disease of the ear, I pare the two lids half-way between the centre and the outer commissure, for a short distance, and secure permanent union with very great improvement. The lids are excessively relaxed, and the patients, before the operation, cannot work for constant weeping. I have done this and seen it done many times, and always with benefit. Following the advice of Von Graefe, I have several times practised a similar canthoplasty in extreme cases of exophthalmic goitre. In some, relief and improvement have been gained; but in others the destructive inflammation of the cornea has seemed to be hastened. In facial paralysis the operation is always beneficial.

PTOSIS.—Ptosis is a drooping of the upper lid from paralysis of the levator palpebræ muscle, or from congenital absence of the muscle. As the other branches supplied by the third nerve are usually implicated, we see at the same time divergence of the eye and inability to move it in any direction but outwards. The pupil is also dilated, and the accommodation paralyzed. When the lid is raised, of course there is harassing diplopia. Hence the ptosis should not be corrected till the divergence and double vision have disappeared. If it then still persist, it may be safely remedied by an operation. Unsightly drooping, and a sleepy expression of one or both upper lids, generally accompany bad, chronic cases of granular conjunctivitis. Should this drooping persist as a serious deformity, after treatment has relieved the disease, it may be corrected by a well-timed operation. Of the methods recommended, I usually prefer the removal of a horizontal fold of skin. The strip removed should extend the whole length of the lid, and should be of the same width throughout, at most not exceeding five millimetres. In all operations on the lids, where skin is sacrificed, it is far better to get too little than too much effect. The excision should not come nearer than four mm. to the free margin. We seek to raise the whole lid equally, and naturally, and not to change the normal position of the cilia. For a beginner, it is safer to dot out with ink the piece to be removed, and to confine himself strictly to that. Careless use of the forceps and scissors, is very apt to lead to disastrous excess and insufficiency of the lid. Too much caution in this respect cannot be enjoined. The wound is closed with a good number of very fine sutures. The elevating effect may be increased by passing the needle first through the lower edge of the skin, and then re-entering it, going deep enough to graze the tarsus, and coming out through the upper edge. The stitches can be removed in twenty-four hours. The swelling and increased weight of the lid make it droop

almost as much as before, and the final effect is not seen until a later period. If necessary, another careful operation may be repeated a few months after.

Other methods are practised and may sometimes do better, such as the use of loops of subcutaneous ligature, recently recommended by Pagenstecher. If loops of sutures, passed under the skin near the free edge, brought out above, and tied, will accomplish the same elevation, there will be less danger of insufficiency, unless the threads are drawn too tight and left too long. In case unsightly folds remain behind, the surplus may afterwards be removed. I have lately had under care a case of congenital drooping of both lids, to such a degree that the patient, a young man, walked with his head painfully drawn back, and chest projecting. Folds were removed and the sutures passed deeply near the upper edges of the tarsi. The result was excellent.

ENTROPIUM AND TRICHIASIS.—A frequent sequel of granular lids, is incurvation or troughing of the tarsal cartilage. This leads to inward displacement of the eyelashes, and trichiasis. In the cicatrizing process of trachoma, the tarsal conjunctiva contracts, atrophies, loses its polish and secreting capacity, and distorts the tarsus horizontally by drawing its two edges towards each other. Rude friction, by the stiffened lid and eyelashes, on the cornea, gives rise to unmanageable keratitis and pannus. Tenderness to light, dimness of vision, frequent attacks of painful ulceration of the cornea, weeping, and endless trouble, are the results. The shrinking process of atrophy leads also to obliteration of the reflected folds, and to much limitation in the movements of the eyes. Moreover, the lids are slowly united at the outer commissure, and troublesome phimosis results, greatly aggravating the trichiasis. Such lesions are permanent, and can only be benefited by surgical treatment. Of the many devices practised for the relief of trichiasis and its consequences, the most unsatisfactory is the mere excision of a horizontal fold of skin. It leads to insufficient closure of the lids, without materially correcting the malposition of the lashes and deformity of the tarsus. Better results are obtained by splitting the lid between the tarsus and the bulbs of the eyelashes, excising a fold of integument, and then stitching so as to slide the lashes with their bulbs up on the anterior surface of the tarsus. Various modifications of this procedure may be practised, but they all leave the main difficulty untouched, in trichiasis from incurvation. The *malformation of the tarsus*, if it exists, is the first and most important thing to be corrected. This is done in different ways. An incision through the skin, and from three to four millimetres from the free margin of the lid, extending the whole length of the tarsus, is first made. To avoid bleeding and greatly facilitate the operation, the ring forceps should be used. The skin being incised to the full length required, and the fibres of the orbicular muscle separated, the white, firm tarsus is properly exposed. Then, seizing it with stout, toothed forceps, and lifting it up, a Graefe's knife is used to take out a wedge-shaped piece, cutting from without inwards, from the whole length of the thickened tarsus. Great care is taken to avoid cutting through and sacrificing any of the conjunctiva. This done, the edges of the skin are carefully united by four or five fine sutures. Instead of trying to remove the whole piece at once, it is better to seize the tarsus at different points, and remove a portion each time, till the end is accomplished. The knife may be made to cut down on one side and out on the other, gradually rotating it as it approaches the conjunctiva. Thus a succession of central, horizontal excisions are made.

There is more danger of not removing enough, than of removing too much of the stiff tarsus. If one or more small holes are made in the conjunctiva, they do no serious harm, but it is best to save that membrane entire if possible. A very narrow strip of skin is to be removed, either before the tarsus is excised,

or after. It should not exceed two or three mm. in width, and this should be equal throughout its length, excepting at each end where the incision runs to a point. The quantity of skin removed should depend on the surplus present, but it is often very disastrous and unnecessary to remove much. If marked phimosis is present, a canthoplasty at the outer angle is to be made at the same time. A great change in the position of the lids may be secured in this way. If the incurvation and trichiasis are slight, a canthoplasty alone may be sufficient to relieve the inversion. In all cases of troughing of the tarsus, and especially where very little if any skin can be spared, I have been much pleased with the operation of Dr. Green, of St. Louis. He everts the upper lid, holds it firmly, and cuts through the conjunctiva and the tarsus in the whole length of the latter. He keeps the incision two mm. from the line of orifices of the Meibomian ducts, and uses a scalpel. A Graefe's knife, held perpendicularly to the tarsus, plunged through, and pushed along carefully, does equally well. If desired, the incision can be prolonged at either end with stout scissors. The ring forceps are not necessary. The effect produced by this incision is to separate the entire margin of the lid from the body of the tarsus, and thus to allow it to be easily everted, and to be held without strain in its new position. A strip of skin from one and a half to two mm. in width, is excised, its lower boundary being about one and a half mm. from the line of eyelashes. The sutures are applied with a curved needle in the usual holder. The needle is entered through the conjunctiva, a little within the rows of lashes, and brought out through the wound of the skin, close to its lower edge. Drawn through far enough, it is again passed under the upper lip of the incision, deep enough to graze the tarsus, and to come out through the skin about ten mm. above the point of entrance. When the suture is knotted, the cutaneous wound is closed, and the loosened margin of the lid is at the same time everted and brought into proper position. Three sutures are usually enough, and they should be removed in twenty-four hours. Healing is prompt, and the gaping tarsus on the conjunctival side heals by granulation, leaving no rigid cicatrix. Very little integument need be sacrificed.

I have seldom resorted to this operation before the trachomatous cicatrization has been completed, but it may be done during the active progress of the disease, to hasten recovery. If necessary, it may be repeated. Where large losses of skin from other previous operations forbid further sacrifice, a simple incision in the skin, and some loosening of the upper lip of the wound, with careful placing of sutures, will suffice. In extreme cases of phimosis, canthoplasty may be combined with this operation. If the tarsus is much hypertrophied, hard, and prominent under the skin, I remove a longitudinal, wedge-shaped portion through an incision of the skin, as above described. With one or the other of these operations, all cases of entropium, incurvation, trichiasis, and distichiasis, can be relieved. The orbicular fibres are preserved in both, and the circulation of the lid margin is not at all seriously impaired.

If the free ends of the eyelashes, from any cause, touch the cornea, they are popularly called *wild hairs*, and must be removed by surgical interference. If they stand free, however, they are harmless ornaments, and should be respected. Spasmodic entropium, occurring usually in old people with relaxed integument, is a serious trouble, and must be obviated. This tendency is increased by bandaging the eyes, as after cataract extractions and other operations. The reflex influence of the displaced lid prompts to still greater contraction and firmer inversion. The annoyance is extreme, and greatly increases the risks of such operations on the eyeball. If possible, the roller should be removed in all such cases, and the eyes kept open. By holding the lower lid down, and keeping the eye open, the inversion is easily overcome. Collodion applied to the skin, and allowed to dry, will often suffice to keep

the lid in place, till the spasm ceases. Various surgical operations, combined with excisions of skin from the lower lid, are practised for its permanent relief. In all operations for entropium, where a sacrifice of skin is thought advisable, great care must be taken to avoid excess. It is always easy to remove a little more integument, at another time, if needed. In people of advanced years with great relaxation and excess of skin folds, a freer excision may be risked. An actual ectropium, or imperfect closure of the lids, or both, after an operation for inversion, is always to be guarded against. Prudent foresight, here as everywhere else, may save the patient's temper and the surgeon's remorse.

CANTHOPLASTY.—The operation of canthoplasty is practised for opposite purposes in different cases. In one it is done to enlarge the too small commissure; in the other to secure its diminution. The latter operation has already been described. The first step in securing increased space is to divide the outer angle with stout scissors or a bistoury. Profuse hemorrhage, in this operation, cannot be avoided, and is a great hindrance. The incision must be in the direct line of the canthus, and should usually extend to the bony orbit. Firm pressure with a sponge will, in a few minutes, control the bleeding, so that the other steps may be executed. The divided corner should be forced widely open by an assistant, everting it as much as possible. The conjunctiva is then seized by the forceps, gently raised, and loosened from its connections with the points of the scissors. This causes it to slide easily, and to cover the raw edges better. Then the conjunctiva and skin are to be stitched together. The first suture is applied exactly in the angle. Two others usually suffice, one above and the other below. Great care must be taken to secure perfect coaptation. Thus the raw edges are kept from readhering. Cold dressings are applied, and in about thirty-six or forty-eight hours the threads may be removed very cautiously. The proper execution of this bloody operation secures freer eversion of the lids, and valuable space. It may often be combined with an entropium operation, and the degree of freedom secured may be regulated by the extent of the incision.

ECTROPIUM.—Ectropium is an eversion of the eyelid, preventing perfect coaptation. It is seen in various degrees, due to various causes. The most serious and frightful cases are those resulting from deep and extensive burns of the face. Scars from wounds of the lids and adjacent parts, from ulceration in skin-diseases, from abscesses and sloughing during facial erysipelas, and from caries of the bony orbit, are all very likely to be followed by this deformity. Chronic blepharitis, with loss of eyelashes and contraction of the skin, from chafing caused by eversion of the puncta and constant weeping, is a common source of troublesome eversion. Then the chronic forms of conjunctivitis with swelling and hypertrophy, lead to constantly increasing ectropium. As the edges of the lids become thickened and relaxed, with the marginal fibres of the orbicularis muscle, the bundles over the orbital edges of the tarsi contract spasmodically, and intensify the displacement. Abscess of the orbit with protrusion of the eye, and extreme exophthalmus in Basedow's disease, are sure to be complicated by inflammatory ectropium. This trouble is much more frequent in the lower than the upper lid, but not so disastrous to the eye. The weeping from displacement of the punctum, especially the lower one, the constant exposure of the everted mucous membrane to irritating causes, and the want of protection to the eyeball, all contribute to increase the deformity and its dangers. In facial paralysis, the swagging of the lower lid sometimes results in total eversion and great annoyance. The paralysis of the fibres of the orbicularis of the lower lid, and the relaxed condition of the

same in old people with chronic conjunctivitis, are important factors in the production of this disease.

The *treatment* of ectropium is palliative, and if possible curative. The first point to be made out, with a view to treatment, is the etiology. If cicatricial contraction of the skin is the cause, that must be relieved in a way best adapted to each case. General rules only can be given: the special modifications must be suggested by the genius of the surgeon. Extensive dissections, torsion and sliding of flaps, and especially great tension after the use of sutures of whatever kind, are very liable to result in failure to heal by first intention, sloughing, and serious aggravation of the original deformity. It is for this reason that skin-grafting and transplantation, after removal of scars and proper preparation, have of late years been so extensively tested. There is no other region of the body where a skilful resort to this safe process is crowned with such brilliant results. If the patient is not completely relieved, he is probably somewhat benefited, with a chance of further improvement in the future. At all events, the case is not made worse by the operation. The great advantage of skin-grafting is that it can be properly employed in the early cicatrizing stages, to prevent as well as to relieve; while plastic operations by sliding, etc., must be deferred a very long time, to diminish the risks of sloughing. In *ectropium paralyticum*, canthoplasty, as already described, is always applicable, safe, and beneficial. As a rule, entropium following trachoma with contraction, or chronic marginal blepharitis, is aggravated by blepharophimosis. To overcome this by dividing the external commissure, and stitching the skin and conjunctiva so as to prevent closure, thus enlarging the palpebral opening, helps very much to relieve the inversion. On the contrary, in treating ectropium, the outer commissure should be pared and united in many cases, as one of the means of affording relief to the deformity.

In some cases, with great thickening of the everted conjunctiva and hypertrophy of the tarsus, an excision of a longitudinal portion of the diseased structures, the wound being closed by loops brought out through the skin below and tied over a small tent, gives excellent results. The wise choice, in each case, of the best method or combination of methods, to suit the peculiarities present, will distinguish the surgeon of tact and experience from the mere cutter. Of all the regions of the body, the face divine calls for the most thoughtful and skilful surgery. A bad job, anywhere else, may be covered up, and in a measure concealed from the gaze of the curious and the critical; but a marred visage is an open reproach to the surgeon, and a source of extreme mortification to the patient.

The treatment of the ectropium which results from deep burns of the face, from caries of the orbit or injuries with depressed cicatrices adherent to the bone, and from mutilations of various kinds, is a department of plastic surgery too important to be dealt with briefly. For the various methods by which these conditions are to be ameliorated, I can only refer the reader to more elaborate works on ophthalmic surgery. Suffice it to say that, with few exceptions, the results are uncertain, and failures often disastrous. In my opinion, efforts to effect a cure by skin-grafting, combined with careful plastic operations, give the most promise for the future. Merely cosmetic surgery, if not brilliantly successful, is not appreciated; and *failures* may likewise be *brilliant*!

SYMBLEPHARON.—To avoid nice distinctions and long names, I include under this head all unnatural adhesions of the lids with one another and with the globe of the eye. To allow the utmost freedom of rotation and easy movement of the lids, a well-lubricated surface and exuberant folds are sup-

plied by the conjunctiva. If the conjunctiva is reduced in its superficial extent by any cause, as by the shrinking process that follows granular lids, two results follow. One is cupping or incurvation of the tarsus; and the other obliteration of the retro-bulbar folds. The former produces more or less rigidity of the lid, and trichiasis; the latter limits freedom of movement. In extreme cases, the degenerated conjunctiva seems to pass directly from the posterior edge of the tarsus to the sclera. This condition is called *posterior symblepharon*, and is incurable. Its evils are enhanced by the dryness of the atrophied conjunctiva, which when extreme is called *xerosis*. In this hopeless degree, the mucous membrane becomes as dry and harsh as the skin. It is the occurrence of this form of symblepharon that deters surgeons from sacrificing a zone of sclerotic conjunctiva in the operation of syndectomy. The directions for that operation are, to incise the conjunctiva entirely around the cornea, dissect it back, and remove a broad band, reaching almost or quite to the equator of the globe. Then the sub-conjunctival tissues are cut or scraped away, baring the sclera completely. This denuded surface is allowed to heal, and, in doing so, it contracts and obliterates the persistent vessels that traverse the cornea and keep up the opacity. The area of the conjunctiva, already much reduced in these cases, is still further diminished. For this and other reasons, I greatly prefer inoculation in extreme cases of pannus, as already stated. The use of jequirity, if equally efficient, would be still preferable to inoculation, because freer from danger. The surface shrinkage of the conjunctiva and the arrest of its secretion are often increased by too severe cauterization in the treatment of granular lids.

Another form of symblepharon is the result of destruction of large portions of conjunctiva by burns or other causes. If the palpebral and ocular conjunctiva are both destroyed, the raw surfaces in contact are sure to unite rigidly. In case the cornea has been destroyed, or severely cauterized, the lids may unite firmly with the entire front half of the ball.

The difficulties in treating this form of adhesion are much increased, if the conjunctiva is destroyed to the bottom of the cul de sac. In that case, it is impossible to pass a probe underneath and around the adhesion, and almost impossible to prevent reunion of the surfaces when artificially separated. The burn often destroys the lid margin, the puncta, and the canaliculi, thus still further complicating the symblepharon. Then again, a hopelessly blind eye, when thus adherent and restrained in its movements, is often painful and detrimental to its fellow. In that case it should be enucleated. A limited symblepharon, especially when a probe can be passed around it, can be carefully detached and kept from reuniting. It is always wise to cover the denuded eyeball, after free detachment, by separating and sliding in folds of conjunctiva from opposite sides, uniting them by fine sutures. Some benefit, and often very satisfactory results, are thus obtained by the skilful adaptation of means to ends.

ERECTILE TUMORS OF THE EYELIDS.—Vascular tumors of different kinds, usually called erectile, often form in or under the skin of the eyelids and face. They are of serious importance, and, when far advanced, always difficult to cure without deformity. Timely surgical interference is always desirable. Whether congenital or not, these unsightly diseases are very apt to increase, if not promptly treated. In some that are well defined and subcutaneous, a careful enucleation is practicable. If cut into, however, alarming hemorrhage is sure to follow. Some form of ligature, either subcutaneous, or, in bad cases, even including the skin, will usually suffice. Acupuncture, and even the galvano-cautery, are often indicated. Coagulating injections are very risky, and I have seldom used them. There is no class of diseases which requires,

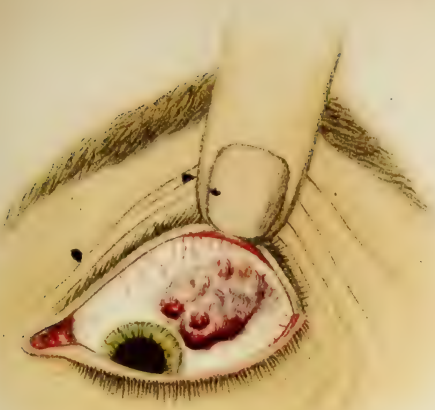
at the same time, more surgical thoroughness and prudence. If the growth originates in, or invades, the conjunctiva, the difficulties and dangers are greatly increased. In the case of a young lady with such a tumor of the conjunctiva scleroticæ, I resorted to subconjunctival ligation and subsequent excision, but the growth again increased. Dr. S. C. Ayres thereupon incised the conjunctiva and dissected it from the tumor, which was then firmly ligated close to the sclera and cut away in front of the ligature. Afterwards a small nodule of vessels remained, which was raised with forceps and snipped away. The recovery was complete. This case is illustrated in Plate XXVII., Fig. 1.

DISEASES OF THE TEAR PASSAGES.

The necessary drainage of the eyes is secured by a system of sewers, composed of the tear sac, nasal duct, and canaliculi. At the inner end of each tarsus is seen a small round opening, the *punctum lachrymale*, which is the beginning of the canaliculus leading to the sac. The lower punctum, by its position, seems to be more important than the upper. In health, the mechanism of the process of taking up and carrying away the tears is explained by the action of the orbicularis muscle, helping the siphon system supplied by the canaliculi. Each punctum rests gently against the globe, where it readily takes up the fluid.

EPIPHORA.—Paresis or paralysis of the circular muscle of the lids, is always attended by a watery eye. This is particularly troublesome in facial paralysis, from whatever cause, and persists as long as the impaired muscular activity. But the healthy action of this muscle can only take away the tears through the puncta when in proper position. Mechanical displacement of these points will lead to constant weeping. Epiphora from this cause alone is often seen in inflammation of the conjunctiva and lids, causing swelling and eversion of the punctum. The same result is produced by contraction of the skin, the presence of lid tumors, hypertrophy of the lachrymal caruncle, chronic blepharitis marginalis, or any other disease that leads to displacement of the punctum. It is often seen in the lax lids of old people, and is explained in the same mechanical way. Some eversion of the lower punctum and troublesome weeping, are constant accompaniments of granular lids. If possible, this annoyance should be relieved by removing the cause. But the constant standing of tears in the eye often aggravates and keeps up the mechanical cause. Hence relief of the epiphora, itself a great boon, may be a means of curing the disease that causes and keeps it up.

Any displacement of the lower punctum is exaggerated when the eye is turned upward. In protracted epiphora from this simple cause, the little opening may be closed up, covered with dry epidermis, and very difficult to detect at all. A faint depression in the dry lid, where it is known that it should be, is its only indication. A small conical probe, gently pressed into it perpendicularly, thence passes on into the sac. When the diagnosis is positive, a very simple surgical operation gives immediate and great relief. I mean slitting the lower canaliculus. The punctum must first be stretched by a conical probe, so as to admit the knife or scissors. A sharp, probe-pointed Weber's knife (Fig 939), or a delicate pair of scissors with a probe-branch, may be used. The latter instrument causes the least pain, and is quickest in its action. The probe-branch is passed into the punctum, and horizontally along the canal, for three or four mm. The scissors are then quickly closed, and the operation is completed. Twice a day for two days, a blunt probe should be



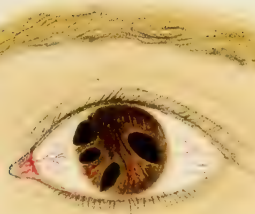
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Morbid Conditions of the Eye.

H. BENCKE.

passed along the slit-up canal, till the edges cease to adhere. By this means the punctum is transferred to a point where the tears can reach it. In very rare cases, troublesome weeping seems due to a hypersecretion of tears alone. In spite of the regular action of the ducts, the eye overflows as a stream in a

Fig. 939.



Weber's probe-knife.

freshet. But the most frequent cause of persistent weeping, is inflammation and obstruction of the lachrymal passages. The force of the inflammation seems to centre in the sac, but the stricture is located in the nasal duct. This condition usually comes on very slowly. Months and even years pass before it reaches a climax. The weeping sometimes disappears in summer, to reappear the following winter, and is always worse out-doors, and in windy, cold weather. At last it becomes constant, the region of the tear sac begins to bulge, and pressure over the sac causes a reflux of mucus or pus through the puncta. With this history, and these developments, the diagnosis of chronic dacryocystitis is established. By slow degrees the lachrymal tumor increases. Some time or other, pressure will fail to empty the collection, and the patient will have acute inflammation and abscess of the tear sac, and, these attacks following at variable intervals, fistula lachrymalis will finally be the result.

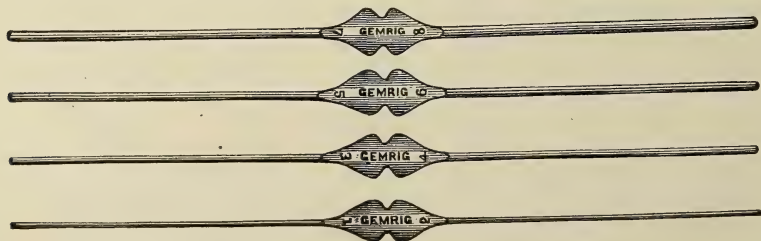
DACRYOCYSTITIS AND LACHRYMAL FISTULA.—Acute inflammation of the sac, abscess, and fistula, are rarely seen, except when preceded by the above symptoms. When the seat and anatomical relations of the tear sac are kept in view, the diagnosis is easy. The tendon of the orbicularis passes across the anterior wall of the sac, and is always raised by the tumor. Pressure over the known region of the sac will generally empty it, forcing the contents through the nasal duct, or back upon the eye. In acute suppurative inflammation of the sac, the point tender to pressure is limited to that region. The seat of greatest swelling and tenderness, the previous history of weeping and other functional troubles, will make it impossible to confound the disease with facial erysipelas, a furuncle over the sac, or anything else. Lachrymal fistula is always *below* the tendon, and near the orbital margin. The presence of a fistula *above* this tendon, anywhere over the upper and inner margin of the orbit, creates at once the suspicion of disease of the frontal sinus. Several such cases have been referred to me as examples of lachrymal fistula. Of course, periostitis, or disease of the os unguis and other bones forming the lachrymal groove and nasal duct, might be confounded with the malady under consideration. But the peculiar history and complications in each case, will clear up the differential diagnosis. I have seen two cases of cyst in the ethmoid bone, resembling lachrymal tumor. Scrofulous subjects, and especially those with persistent ozæna, are the most constant victims of obstruction in the tear passages. In all persons afflicted by chronic inflammation of the nasal mucous membrane, tear-sac difficulties are liable to occur. Rarely, conjunctivitis, acute or chronic, seems to follow the canaliculi into the sac, causing granulations and obstruction. Further than the fact that these local and constitutional peculiarities predispose to this class of diseases, we know but little of their etiology. We very seldom see them in sound people, with healthy mucous membranes. Troubles of the tear sac rarely recover spontaneously, and, when they do, it is after an acute abscess. The *treatment* may be palliative or curative. Gentle pressure, twice a day or oftener, to keep the

distended sac free from accumulations, and the use of mild, local astringents, with care in avoiding exposure, constitute the measures which may be employed for palliation. A surer way to stave off acute abscess is to slit the upper canaliculus quite down to the sac, so as to give free and easy vent to the irritating secretions. This allows also of more thorough cleansing of the diseased sac by syringing. These measures, however, only help in keeping matters from growing worse.

The radical and complete cure of dacryocystitis and its consequences, is seldom accomplished, but great relief and comfort, often quite satisfactory to the patient, can nearly always be expected. The first and essential step in the curative treatment, is surgical. Free access to the sac must be had, to allow of the necessary treatment of the diseased mucous lining and of the stricture. There lingers still, in the popular mind, an impression that a precious tube, of some kind, must be placed in the nasal duct, but the use of such an instrument has long since been abandoned, as well as all means of dilatation through an opening in the skin. These obstructions are now treated exclusively through the natural channels, and generally through the upper canaliculus. This is slit well down into the sac, and kept open, as mentioned above. For this purpose a Weber's probe-knife is the best instrument. The patient should sit on a low chair, or, better, lie on the operating lounge. The surgeon stands behind the head for the right eye, and in front for the left, using of course his right hand. The punctum must have been dilated, with a conical probe, so as to admit the knife. An assistant renders the canal tense, by drawing the skin of the lid outwards and upwards. The knife is passed in till it reaches the cavity of the sac, and till the blunt point rests firmly against the inner bony wall. Then keeping it firmly there, the hand is slowly raised and the mucous membrane divided well down into the corner. Without withdrawing the knife or relaxing the pressure against the inner wall, it is raised to a vertical position, pushed gently downwards, the edge turned a little forwards, and made to incise or notch the sac. Thus free admission is secured for a large probe.

It is better that the sac should be distended at the time of the operation. This facilitates the different steps, and shows when the sac is well opened, by a gush of mucus. Slight bleeding takes place, but it is soon over. It is seldom necessary to give ether. Waiting a few minutes, the probe may be passed in for exploring and overcoming the stricture. A full set of Bowman's flexible silver probes (Fig. 940) must be at hand. But for safety, and

Fig. 940.

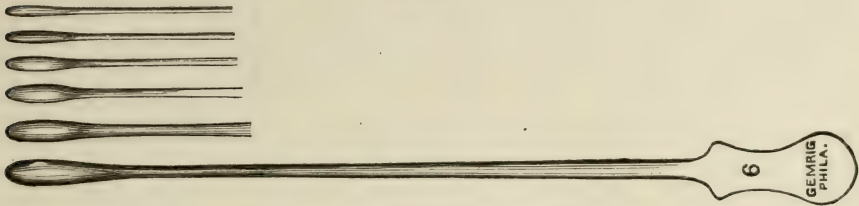


Bowman's probes.

for certainty as to the seat of the stricture, I have for many years used probes with bulbous expansions near the end (Fig. 941). The enlarged end is about ten mm. long, and the thickest portion in the middle. The rest of the instrument is decidedly smaller. Two of different sizes, one two mm. and the other two and one-half mm. at the thickest part of the bulb, may be made on oppo-

site ends of the same instrument, with a flat surface in the centre, as in the double probes. The length of each probe, from the flat middle, should be about five and one-half cm. The probe is gently curved, so as the more readily to pass through the sac and nasal duct, without inconvenience from the prominent

Fig. 941.



Williams's bulb-pointed probes.

brow. It is impossible for such an expansion, when once fairly in the sac or bony canal, to pierce the mucous membrane and make a false passage. When the stricture is reached and the resistance overcome, the yielding is sudden, and indicates its exact seat and extent. If the strictures are multiple, the seat and existence of each are determined.

The smaller bulb is introduced first. If the sac is not opened enough to admit it, the notching can be repeated. Great care should be taken to get surely and fairly into the sac with the bulbous end. Then the probe is turned vertically, and pushed gently and slowly downwards in the course of the nasal duct. When the obstacle is reached, a little patience and slowly increased pressure will suddenly triumph over it, and the probe will then pass readily down into the nose, where it is firmly arrested by the solid floor of the inferior meatus. The instrument is then gently withdrawn and the larger bulb passed through in the same way. If the stricture is very rigid and the canal almost closed, some blood will escape from the nose, but otherwise none may be seen. This part of the operation, if skilfully executed, greatly simplifies and expedites the after-treatment. Generally it is better to do nothing more than keep the opening into the sac free for a week or more. If there is much discharge, the sac should be washed out each day with a syringe from above. A dentist's rubber syringe bent at right angles near the end, with a smooth point, and tepid water, are all that is needed. If, when the nozzle is fairly in the sac and directed downwards, the water does not readily flow into the nose and throat, there is something wrong, and the parts should be re-explored. I venture to say, from a large experience, that if in all cases of dilated, suppurating tearsac, with or without fistula, this much were thoroughly well done, and the rest left to nature, most of the patients would be so much benefited as to feel satisfied with the result. In some the troubles will come back, but very seldom, if ever, in the old, aggravated form. In Stilling's mode of treatment, the stricture is deeply incised in different directions, and little or nothing more usually done. Of course, if there is syphilitic or scrofulous caries, with the diseased sac, no very satisfactory result can ever be obtained.

In the hope of securing better results in the long run, I have for many years used the bent silver styles, worn in the duct for several months. They are made of pure, virgin silver, four and one half cm. long, slightly conical at each end, and of different sizes, varying from one to two mm. in diameter. One end is bent into a moderate curve, leaving the straight part three or three and one-half cm. long. Close to the beginning curve the style is again bent outwards, so that when inserted, and the hook turned forwards over the

lower lid, it will keep its comfortable position. Otherwise it will be dragged round against the eye by the lid. The outward bend is different for the two sides. By a little experience in the use of the pliers, and in fitting the length to different eyes, it is easy to get the suitable curves and the right length, so that the style will fit close up in the corner, rest gently on the lower lid, be touching or almost touching the floor of the nostril, and be worn without inconvenience or unsightliness. In most cases, I prefer not to use the style. If the thorough operation for freeing the passages, already described, is followed by rapid contraction of the sac and diminution of the discharge, I prefer occasional syringing with tepid water or mild astringents. If the troubles persist, or frequent relapses occur, then a resort to wearing the style may be a great aid. In one respect its use is more agreeable to the patient. After the first few days it is not nearly as painful as dilatation by the occasional passage of the probe. But whatever method of combating the stricture may be thought best in any case, the use of the syringe must always enter freely into the treatment, if there is much enlargement of the sac and profuse secretion. In that event, if the style be employed, it must be removed every day or two for thorough cleansing with tepid water, or the injection of astringents, if that fails. When little or no further secretion is present, the style can be worn for weeks together without removal. The style, of course, must be comfortably fitted to each case, if good is expected. In first placing it, and sometimes in replacing it after removal for syringing, it may not readily enter. Its short, curved, and awkward shape makes the manipulation difficult. When this trouble is experienced, the full-sized probe may be passed and immediately followed by the style. Its reintroduction is more apt to be difficult after the use of astringents to the sac. To combat the discharge, if not promptly cured by wearing the style, syringings with tepid water and astringents must be used. About the best is a ten-grain solution of sulphate of copper, a few drops drawn into the syringe and passed through after thorough cleansing with tepid water.

When the suppuration is controlled, and the patient is allowed to go home, the surgeon should insist on his immediate return if the discharge grows worse in spite of wearing the style and the observance of proper care. After the first thorough operation, if all the symptoms improved rapidly, I would simply cleanse the sac when needed, by tepid syringing, and wait. If the case came to a stand-still, or got worse, I would pass the probe and let it remain for half an hour, once or twice a week, continuing the necessary medication of the sac. If, after a few weeks, the case did not progress well, I would fit a suitable style and see that it was comfortably adapted. Not much attention need be paid to complaints of lachrymation, as long as it is not attended by undue secretion of muco-pus. This can only be remedied by free dilatation of the stricture and faithful medication with the syringe. I have seldom failed to find rapid and great improvement after the first free use of the bulbous probes. In cases with a fistulous opening through the skin, I prefer to pass the probes through it into the sac, and down to the nose. As we have this convenient way into the sac open, immediate and large dilatation of the stricture may be thus practised, and is always followed by closure of the fistula and great amelioration. Now and then, nothing more is needed; but, if required, the upper canaliculus may be slit and the usual treatment continued. Where the sac is so large that no treatment can be expected to bring it to reasonable dimensions, a large portion, or the whole of it, may be dissected out. I did this recently with the happiest result. The patient had chronic ozæna, and profuse suppuration from a large lachrymal tumor. Having etherized her, I made a long incision and dissected out the sac with an enormous diverticulum. The wound was closed with sutures, and healed

by first intention, and in a few days she was well. By "well," I mean relieved of the unsightliness and disgusting suppuration. With this she was entirely satisfied. The same result is here obtained as in the old method of destroying the tear sac by the actual cautery. In caries or hopeless closure of the bony duct, destruction of the sac is the best that we can do. Extreme relaxation of the sac is best relieved by enucleation, as above. It is surprising how little such patients are troubled with weeping after the source of the irritation is dried up by obliteration. Such eyes weep when exposed to the wind, or under the influence of the emotions, but not much at other times.

Surgical measures, in the treatment of chronic suppuration of the lachrymal sac, are thus reasonably successful, but the complete cure of the weeping is an exception. Injuries of the canaliculi, especially of the lower, are often seemingly trifling, and yet are followed by incurable lachrymation. If cut across, torn away, or destroyed in their whole length by burns or bruises, it is seldom possible to re-establish their permeability. Great care is required in removing small tumors or other growths from the lids near the inner commissure, not to cut away these delicate but important structures. Rarely, the canaliculus may become obliterated without injury or known cause. At other times, a stricture is found in its course, that can be overcome with a small probe, and the epiphora relieved. The thorough removal of epithelioma of the lids may require the sacrifice of these little ducts, and of course the weeping then is permanent. Occasionally a little calculus may form in the canaliculus, causing suppuration and weeping. It is easily detected and removed, as are the little mushroom growths that cause similar troubles. Persistent weeping is often kept up by ulceration in the nose, and may be mistaken for stricture of the tear passages. I have a patient now under treatment, who came for an operation on the tear sac. She is already relieved by applications to the nasal mucous membrane. Troublesome weeping may also be caused and kept up by a polypus or other growth in the inferior nasal meatus. Such possibilities should never be forgotten, particularly when long standing weeping is not attended by suppuration in the sac itself. Of course, caries of the turbinated bones, or foreign bodies in the nose, may give rise to the same trouble. In the few cases of suppurative inflammation of the tear sac in infants, that I have met with, they have been relieved by a single free dilatation through the opened canaliculus. Calculi and other formations in the tear sac are rare, but must be recognized and removed.

OPHTHALMOSCOPIC DISEASES.

Alterations behind the lens can only be made out by the aid of the ophthalmoscope. Even in luxations of the lens, the mirror is of great use in diagnosis. For optical reasons, the edge of the lens, when transparent, is seen as a dark border, and readily identified. In the differential diagnosis of cataract, in its incipiency, fundamental illumination of the eye must not be neglected. Oblique illumination alone, in old people, except when distinct striæ are detected in the lens, is likely to lead to a false belief in the existence of cataract. Ophthalmoscopic results may be positive or negative, each kind having its value. In growths of the retina and choroid, at an early period, when clear diagnosis is very important, the eye mirror is indispensable. The functional test must not be omitted. A sharply defined blank in the field of vision (scotoma), in a suspected tumor of the fundus, helps to confirm the diagnosis. Any inflammatory or other organic lesion in the retina, choroid, or vitreous, may give rise to a more or less well-defined scotoma, which is

a constant result of detachment of the retina, of hemorrhages, in or under the retina or the choroid, of patches of choroido-retinitis, of tumors in the fundus, and sometimes of foreign bodies, or extravasations of blood in the vitreous. (Plate XXVIII., Fig. 2.) It is not pathognomonic of any one of these lesions. Rarely, it is caused by the embolic plugging of an arterial branch in the retina or choroid. The same defect in the field of vision is sometimes the result of extra-ocular alterations, either in the optic cord or the brain. In such cases, the finding is negative. Lesions of the optic tract, however, are more likely to produce some form of hemiopia or sector defects in the field. In such instances a negative result may be of very positive value in fixing the diagnosis, on the principle of exclusion. The perimeter, or the black board, will enable the surgeon to map out the scotoma.

All disorders that lead either to cloudiness of the vitreous, or to profuse intra-ocular hemorrhages, make the illumination of the fundus difficult if not impossible. If the vitreous is semi-transparent, a red reflex may be had from the bottom of the eye, and perhaps glimpses of the optic papilla and other structures. In that case, numerous floating corpuscles will probably be seen in the liquefied vitreous. Slight movements of the eye under inspection help to identify them. If the hemorrhage has been profuse, and close behind the lens, no red reflex can be had from the bottom. The coagulum may then be seen by the ophthalmoscope, or by oblique illumination, in its natural red color. Hemorrhages in the eye are always of serious significance, occurring in the gravest diseases, or indicating a state of the arteries that make apoplectic effusions in the brain very probable. Even spontaneous ecchymosis under the conjunctiva, in itself harmless, is of serious import in persons of advanced years. I have often seen it as the precursor of paralysis. The most hopeless form of glaucoma is that which is complicated by intra-ocular hemorrhages. Indeed, the frequent occurrence of ecchymoses in the retina, in connection with any disease, is an alarming symptom. (Plate XXVIII., Fig. 6.) In old people it portends glaucoma. In the young it signifies a fatal hemorrhagic diathesis. Such cases should be closely watched for years, lest they end in destructive glaucoma. Intra-ocular bleeding, alone or complicating local diseases of the eye, may be indicative of organic lesions of the heart or kidneys, of the hemorrhagic diathesis, of malignant anæmia, or of a degenerated state of the arteries. A rigid inquiry in all these directions should be insisted upon. In rare cases, the phenomenon is unaccountable. I have now under treatment a temperate and well-preserved man of sixty years, who has had the most extensive retinal hemorrhages I have ever seen, first in one eye and then in the other. He seems to be absolutely sound, but is, of course, liable to an apoplectic attack, of which, however, there is now no premonition whatever. If he escapes that, I shall expect to see glaucomatous manifestations at some future day.

In syphilitic choroiditis, the vitreous is often filled with fine opacities, that rise up like clouds of dust when the examined eye is slightly moved. If the turbidity is great, the outlines of the fundus may not be at all visible. At a later period, when this fluid has again cleared, extensive atrophic patches in the choroid may be discovered.

In the acute forms of glaucoma, the cornea, aqueous and vitreous are often so hazy, that direct ophthalmoscopic diagnosis is impossible. Such diagnosis presupposes perfect, or at least partial transparency of the dioptric structures. Opacities in any or all of these, if large and dense, preclude the use of this valuable instrument. Other means of diagnosis must then, especially, be strained into service, as I have already pointed out with some detail.

A false fear of the brilliant light in ophthalmoscopic examination, prevails among patients. But in intelligent hands there is no danger whatever. It



Morbid Conditions of the Eye-ground.

is always best to look a little obliquely into the eye, at first and at all times, except when the region of the macula lutea is inspected. In this way the light is not at all painful, nor even dazzling. In the diagnosis of delicate changes in the direct line of vision, dilatation of the pupil is indispensable.

There are two methods of examining the eye with the ophthalmoscope—one called the direct, and the other the reversed. In the former, the objects in the fundus are seen in their natural relations. With the latter, they are reversed, above appearing below, and right left. We speak likewise of the erect and the reversed image. In direct examination, the examined and examiner's eye must be naturally emmetropic, or rendered so with glasses, and the accommodation in both relaxed. Moreover, the surgeon must approach as closely as possible the eye inspected, bringing his eye almost in contact with it. To do this successfully, the right eye must be trained to look at the right eye of the patient, and *vice versa*. In this way alone can he avoid colliding of noses. By the reversed method, with a convex lens of three or four inches held before the examined eye, there is greater liberty, and all sorts of cases can be examined with more ease. Both methods should be employed in most instances, the one helping to control and explain the other. In ophthalmoscopic examinations, the parallax movement of objects, at different depths in the eye, is very striking and of great value. This phenomenon is particularly useful in judging of opacities in the vitreous, and estimating excavations of the optic papilla, as in glaucoma. Beginners are very prone to diagnose *congestion* of the optic nerve, but experts know the extreme difficulty of recognizing this condition, and are more cautious. Serious impediments to the retinal circulation lead to swelling of the papilla, tortuosity of the veins, ecchymoses, and other unmistakable alterations. As the percipient elements of the retina, the rods and cones, as well as the vitreous humor, are nourished by the chorio-capillaris of the choroid, it follows that in nearly all the serious disturbances of the choroidal circulation, the vision is impaired, and the vitreous becomes cloudy. Effusions into the vitreous, from the optic nerve or retina, or hemorrhages, remain close to the part diseased. Impairment of sight from lesions of the choroid, involving directly the terminal nerve elements, is much greater than in more marked changes in the vascular layer of the retina. It is often amazing to find very slight dimness of vision in enormous swelling of the optic nerve, and in other alterations equally grave of the retina. It is not safe to base an opinion of the severity of slight disturbances, on the ophthalmoscopic appearances. Functional tests must always be applied first, and are often surprising. A set of test types, which is easily obtained, will enable the surgeon to try the acuity of vision, both for distance and for reading, and to ascertain the accommodation.

A critical examination of the eye and its delicate functions, is often an important aid in the diagnosis of diseases elsewhere. For example, in tumors within the cavity of the cranium, we often have optic neuritis, involving both eyes. Its presence in the two eyes at once, or in short succession, directs suspicion to the brain immediately. It may appear at any period of the morbid growth, and usually persists till the fatal termination, often lasting for years with its most characteristic symptoms. These are great swelling and prominence of the papilla, extreme tortuosity of the retinal veins, blurring of the natural boundaries of the disk, and, frequently, patches of extravasated blood in the retina. Single optic neuritis from other causes, is frequent; as in young women with suppressed menstruation, in syphilitic and albuminuric subjects, and in some instances where no general disease can be made out. It is sometimes a grave symptom of lead-poisoning, and is apt to lead to atrophy and great damage to vision, if not to its total abolition. Single

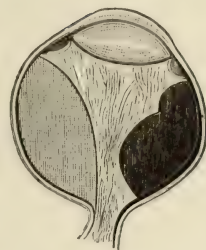
or double, it is occasionally recurrent, coming or going with fluctuations in the disturbances that give rise to it. In children with tubercular meningitis, neuro-retinitis is rarely detected. In such subjects, tubercular deposits in the choroid are more frequent. Optic neuritis in a milder form, but combined with very striking, and often characteristic, changes in the retina, is a frequent indication of albuminuria. Sometimes the retinal changes alone are detected, and these have often led me to the diagnosis of serious disease of the kidney before it has been suspected by the attending physician. A chalky-white group of deposits, often radiating in lines from a centre, and usually in the region of the macula lutea, at once suggests a renal origin. It is rarely seen in other diseases, and in albuminuria is not always so characteristic. (Plate XXVIII., Fig. 4.) Retinitis in any form should lead us always to inquire into the constitutional condition of the patient. Retinal diseases are more common than cataract, in diseases of the kidneys, but both may exist together, and hemorrhages into the eye are not at all uncommon.

In locomotor ataxia, certain eye symptoms are among the first to attract attention. Diplopia from disturbances in the rotatory muscles of the eyes, is very common. I recall the case of a man whom I treated for paralysis of the external rectus of one eye. He recovered from this, after a long course of treatment which lasted about a year. Some years after, he consulted me for a failure of vision in one eye. My attention was then attracted by his very small pupils. With the ophthalmoscope, I recognized some pallor of the optic papilla, the first evidence of optic atrophy. This continued slowly to increase, with failure of vision, till he is now totally blind, not even perceiving light. His pupils have remained very small from the beginning. As long as useful sight continued, the size of the pupils was uninfluenced by varying degrees of light. But the moment a small object, held near him, was focused, the pupils contracted, to dilate to their usual small size when accommodation ceased. This failure to respond to light, and movement with efforts of accommodation, are characteristic of tabes dorsalis. This peculiarity of the pupils and optic nerve-atrophy, with failing sight, often precede, for months and even years, the disturbances of muscular equilibrium. The patient just referred to, still walks well, and has perfect use of his mental faculties, though long since completely blind. I call attention to this state of the pupil, in connection with the ophthalmoscopic evidences of optic atrophy, on account of its diagnostic importance. (Opacity of the optic nerve-fibres is shown in Plate XXVIII., Fig. 5.)

INTRA-OCULAR TUMORS.—I have only spoken of these neoplasms incidentally, in treating of the diagnosis of eye troubles without the use of the ophthalmoscope. Whatever be the nature of these growths, and whether commencing in the retina or choroidal tract, destruction of sight is the inevitable consequence. If not removed very early, the system will be contaminated, and fearful suffering with a fatal result is sure. Indeed, even when detected in their first development, and the eye at once enucleated, relapse and a lethal termination are very apt to occur. The fact that an experienced surgeon will not promise a certain cure, often leads patients to wait and take the risks, rather than submit to enucleation. Mutilation, with a certainty of saving life, is hard to submit to; but when no great assurance is promised against relapse, most persons prefer trusting to Providence. Still, an early enucleation may and often does afford permanent protection. Even if it fails, a respite is secured, and the extreme agony of a cancerous eye is avoided. An intra-ocular growth is often far advanced before it is detected. This is especially apt to be the case in small children. Till the eye is distended by the neoplasm, there is little or no pain. But glaucomatous hardness and paroxysms

of extreme suffering come at last. In this stage, the diagnosis is usually easy. Still, in adults, the case may be mistaken for simple glaucoma, till later developments. Now and then, I have seen a sarcomatous tumor developing in the ciliary region, mistaken for cataract or for a luxated lens. A very little skill will prevent such a blunder.

Fig. 942.



Section of eyeball showing an intra-ocular tumor.

The annexed wood-cut (Fig. 942) represents the section of an eye removed from a lady 39 years of age, who, about six months before coming under observation, accidentally discovered that her right eye was very imperfect. She could barely see objects around the room. The eye up to that time had never been painful, and had never been injured, but since then the eye had become entirely blind, and was now at times quite painful. The eye was abnormally hard. The iris was pressed forward, in contact with the cornea, and it was impossible to obtain more than a red reflex from the fundus, and that only on the inner side. On the outer side was seen the rounded outline of a choroidal tumor. The eye was enucleated December 9, 1881, and after hardening in Müller's fluid was opened by vertical section. The tumor was found attached outwardly, and was 18 mm. in length and 8 mm. in thickness. The retina was detached and funnel-shaped.

[RETINOSCOPY: THE SHADOW-TEST.]

Under the name of the *shadow-test*, a ready method of estimating the refractive condition of the eye has been recommended, and may here be briefly referred to. It has been ascertained that if a lamp be placed above the patient's head, and the fundus oculi illuminated by means of an ophthalmoscopic mirror of 10-inch (25 cm.) focal length, held at a distance of four feet (120 cm.), there will be seen a bright area of the retina, surrounded by a dark border which is the shadow of the iris. If now the patient's eye be *emmetropic*, when the mirror is tilted the light area will be displaced in the opposite direction, but no distinct line of demarcation will be observed between the illuminated part and the shadow; if, however, the eye be *myopic* there will be a distinct linear edge to the shadow, moving in the same direction as the mirror, and in a case of *hypermetropia*, a linear edge moving in the opposite direction. By noting the strength of the glass, convex or concave, which will cause this shadow-edge to disappear, the observer can estimate the degree of ametropia with sufficient accuracy for all ordinary purposes.]

EXPLANATION OF PLATES ILLUSTRATING INJURIES AND DISEASES OF THE EYES.

PLATE XXVII.

- Fig. 1. Episcleral Angeioma.
Fig. 2. Cyst of Iris, after removal.
Figs. 3, 4. Multiple Pupils of both Eyes.¹
Fig. 5. Buphthalmus.
Fig. 6. Penetration of Birdshot through Ciliary Region.

PLATE XXVIII.

- Fig. 1. Rupture of Choroid.
Fig. 2. Central Choroiditis with Scotoma.
Fig. 3. Rupture of Choroid with Pigmentation from Retinal Hemorrhage.
Fig. 4. Retinitis Albuminurica.
Fig. 5. Opaque Optic Nerve-fibres.
Fig. 6. Acute Neuro-retinitis with Hemorrhages.

¹ From a patient sent by Dr. C. Kearns, of Covington, Kentucky

INJURIES AND DISEASES OF THE EAR.

BY

ALBERT H. BUCK, M.D.,

OF NEW YORK.

EXAMINATION OF THE PATIENT.

TESTS OF THE HEARING POWER.—In all the different forms of ear disease, with the exception, perhaps, of those of the auricle, it is a matter of great importance to ascertain how far the patient's power of hearing is impaired. In the case of an adult, considerable dependence may be placed upon the individual's own statement with regard to this point; but in that of a child, the information desired must be obtained from the parents or guardian. It will not do, however, to depend entirely upon this sort of evidence: we must supplement it with that which may be obtained by means of certain simple tests. The ticking of a watch, and words or sentences spoken either in a whisper or in an ordinary tone of voice, constitute the only tests which have ever been employed to any great extent. Of the two, that which is based upon the employment of articulate speech, is the one more commonly employed, and the more satisfactory. At first we employ it, not in a formal manner and with the consciousness that we are using a test, but unconsciously, in the simple routine of ascertaining the patient's history. If in this way we have learned that only one ear is probably affected, our judgment with regard to the patient's general acuteness of hearing cannot safely be taken as furnishing a correct estimate of the hearing of the affected ear. A more formal test then becomes necessary. For example, the patient should be told to close firmly the unaffected ear with his finger, and to sit or stand in such a position that the physician's voice may be directed toward the affected ear, which remains open. In the case of patients who are decidedly deaf in both ears, we must not forget the fact that they often possess the power of "reading the lips" to a remarkable degree. Under these circumstances the patient should sit with his face turned toward the physician, but with his eyes closed. Furthermore, he should be required to repeat the exact words spoken by the physician. In testing the hearing with the watch, it is better to hold it first at a point which lies beyond the hearing distance of the ear which is being tested, and then to gradually bring it nearer and nearer to the ear, until the patient is able to distinguish the sound of the ticking. As a rule, it is not necessary to ask the patient to close the other ear during the progress of the test, as the ticking of an ordinary watch is a sound of too great feebleness to reach the opposite ear. The proximity of a wall, door, or other reflecting surface, may, however, render such a precaution necessary. If the hearing is markedly affected, the ticking of the watch may not be heard even when it is pressed firmly against the auricle. In this connection it should be remarked that a patient who fails to distinguish the sound of the ticking when the watch is pressed against the auricle, will often hear the sound quite

distinctly when the watch is pressed against the temple, or against the mastoid process. In the case of a young child, we are obliged to depend very largely upon the statements of the parents with regard to the condition of the hearing.

A tuning-fork so constructed as to maintain its vibrations for a comparatively long time, and not pitched higher than the middle range of the musical scale, will be found very useful for the purpose of communicating sonorous vibrations to the auditory nerves through the skull.¹ It is not always an easy matter, however, to determine correctly the significance of the results of this test. In a certain class of cases, the test produces results which are positive, and which can only be interpreted in one way. I refer to those cases in which the sound of the tuning-fork is heard better by the patient in the affected than in the unaffected ear. It is evident, in such cases, that the deafness complained of is not due to any lack of power in the auditory nerve, and that we are simply dealing with phenomena of reflection and reinforcement of sound, such as may be produced by a swollen drum membrane, or by cerumen impacted in the external auditory canal, or by a finger placed lightly over the outer orifice. In another class of cases, however, the problem is not so readily solved. In these cases, the patients have recently become markedly or completely deaf in one ear, and, when we subject them to the tuning-fork test, we find that they hear the sound of the fork only in the unaffected ear. In such cases it has been customary to maintain that the auditory nerve must be the seat of the lesion which has caused the deafness. This is not the place in which to discuss this question in detail, and I will therefore simply state my own belief with regard to it in very brief terms. Changes in the drum-cavity, and particularly in those parts of it which are known as the oval and round windows, are, it appears to me, competent to prevent the perception of sounds by the adjacent auditory nerve. In order that the auditory nerve may transmit sound-sensations to the brain, it is necessary that a vibratory motion should take place in the cochlear structures among which the auditory nerve-filaments terminate. No provision exists in these structures for lateral vibration, but only for one following a direction at right angles to the plane of the lamina spiralis. Such a mode of vibration, however, can only take place when at the same time both the foot-plate of the stirrup and the secondary tympanic membrane are mobile; or, in other words, when the increase in breadth of the column of fluid occupying the scala vestibuli can be compensated for by a corresponding diminution in breadth of that occupying the scala tympani; for these changes in the diameters of the two columns of fluid represent the mechanical result of an excursion inward (toward the vestibule) of the foot-plate of the stirrup, while upon the return excursion of this ossicle (outward toward the tympanum), the relations of the diameters of the two columns of fluid are reversed. This brings us then to the following conclusion with regard to the loss of power to perceive sound under the circumstances mentioned above, viz., that this loss of power may be produced by any one of the following conditions, beside that of actual paralysis of the nerve itself:—

1. Immobility of the foot-plate of the stirrup.
2. Immobility of the secondary tympanic membrane.

¹ The heavy, prismatic tuning-forks are the best, as they maintain their vibrations for quite a long time. They are kept for sale by all the surgical instrument-makers, and may be used either with or without clamps. The common practice is to strike one branch of the fork flatwise against some hard object, covered with cloth or leather, and then, while the instrument is still vibrating, to rest the lower end of the handle against the forehead, the top of the head, or the teeth of the patient.

3. Marked increase in the tension of the fluid contents of the labyrinth, due to

- a. rupture of a bloodvessel and escape of blood into the labyrinth;
- b. simple fulness of the bloodvessels;
- c. extreme pressure of the foot-plate of the stirrup upon the labyrinthine fluid; all of which conditions are competent to greatly increase the pressure upon the contents of the labyrinth.

In actual practice these distinctions are of little value. At the same time, they sometimes help us to explain satisfactorily those rare cases in which the hearing is rapidly lost, and then afterward is almost as rapidly restored.¹

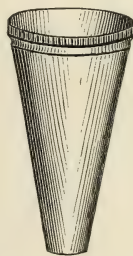
INSTRUMENTS AND METHODS OF EXAMINATION.—It is a matter of the first importance that the physician who contemplates studying diseases of the ear, should be provided with good instruments. Badly devised or clumsily constructed instruments will make it impossible for him, in many cases, to arrive at a correct diagnosis, and, in other cases still, he will, by their use, cause the patient much unnecessary discomfort or even pain.

In a few individuals, the external auditory canal is so broad and straight that the physician can see its walls throughout their entire length, and even the drum-membrane, by direct inspection, without the aid of instruments of any kind. In the majority of persons, however, a satisfactory view of these regions cannot be obtained except with the aid of two kinds of instruments, viz., one to push aside the soft walls of the orifice of the canal (ear specula), the other to illuminate the parts thus rendered accessible (mirrors of various kinds).

Of the different patterns of *ear speculum* which are offered for sale in the surgical instrument-makers' shops, the cheapest and at the same time the best is that known by the name of Wilde's ear speculum. (Fig. 943.) This instrument represents a truncated, hollow cone of coin silver, polished within and without. The cheaper variety, which is made, I believe, of "German silver," is a very poor substitute for that made of coin metal. For all ordinary demands, three different sizes of ear speculum will be found sufficient. They should all be of about the same length, but their calibres should differ. The aperture, at the smaller end of the instrument, should measure not less than three and a half millimetres in diameter, for the smallest of the three specula, and not more than seven millimetres for the largest. The walls of the instrument should be no thicker than is sufficient to prevent them from bending under ordinary manipulations. It is scarcely possible at the present time to purchase ear specula that are not very faulty in this important respect. It is necessary to have them made to order.

For purposes of illumination, either the *hand-mirror* or the *forehead-mirror* may be employed. As far as the mirror itself is concerned, these two are one and the same thing. In practice it has been found that the best illumination is obtained with a concave mirror of circular form, and possessing a focal distance of from twelve to thirty centimetres, according to the requirements of the visual power of the observer. A focal distance of about twenty

Fig. 943.

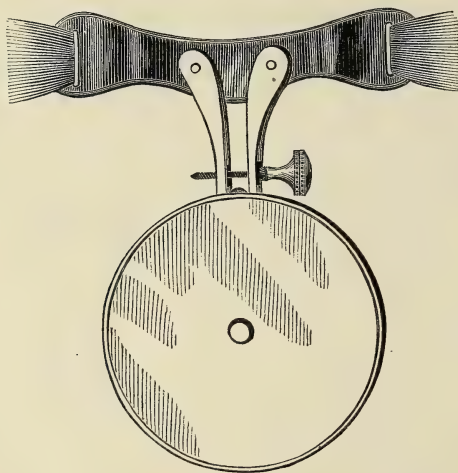


Wilde's ear speculum.

¹ I have recently seen a case of chronic congestive catarrh of one middle ear, in which, during some of the exacerbations, the hearing power of one ear (for sounds of either the voice or the vibrating tuning-fork pressed against the forehead) was completely obliterated. With the subsidence of the more marked congestion of the tympanic mucous membrane, the hearing returned to a very useful degree, the patient being able to correctly distinguish words spoken in an ordinary tone of voice at a distance of ten or fifteen feet.

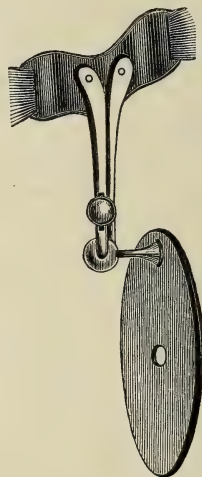
centimetres is that which is best adapted to all the ordinary purposes of the aural surgeon. If the mirror be held in the hand, it is probably better to place the eye in the focal line, that is, to look through the small central aperture with which these mirrors are usually provided. If the instrument, however, be worn on the head, the mirror should be brought down so as to rest on the bridge of the nose, or in close proximity to it, and the physician should look into the ear over the upper edge of the mirror. Here, again, it will be found that the forehead-mirrors kept for sale in the instrument makers' shops, are not constructed with a view to their being employed in this fashion, the space left between the upper edge of the mirror and the forehead-plate being almost invariably too narrow. They are also, as a rule, defective in another respect, viz., that the ball-and-socket joint, by which the mirror is attached to the forehead-plate, allows the former to be rotated to such a limited extent, both from side to side and from before backward, that the observer will often find himself unable to use the source of light which may happen to be available, unless he changes its position, or that of the patient, or both. This joint should have the greatest freedom of motion possible, for then only will the physician readily be able to utilize almost any source of light that he may find at hand. The accompanying cuts (Figs. 944, 945) show the details of construction so well, that I may omit any further

Fig. 944.



Forehead-mirror. (Half the natural size.)

Fig. 945.



Forehead-mirror. Profile view.

description of this instrument, which I consider to be a thoroughly serviceable type of forehead mirror. As represented in the cuts, this mirror is essentially the same as that first devised by Dr. Robert F. Weir, of this city, in 1869 or 1870. At that time the forehead-plates were usually made of hard rubber, but now the best are made of metal, with an outer plating of nickel. There should be no padding, and the flexible band attached to the plate should not be made of any dyed material, as the moisture of the temples is apt to make the dye run.

As far as the *actual examination* of the auditory canal and drum-membrane is concerned, I shall mention only the points which are of the most importance. Among the readily available sources of light for illuminating the deeper parts of the ear, the best is the broad flame of a burning gas-jet

(preferably the argand gas-burner), or that furnished by a good kerosene lamp. Even a lighted candle, if held sufficiently near, may suffice. Direct sunlight is too dazzling. Indirect sunlight, such as can be obtained if we direct our mirror toward the sky above the horizon, or toward the white wall of a

Fig. 946.



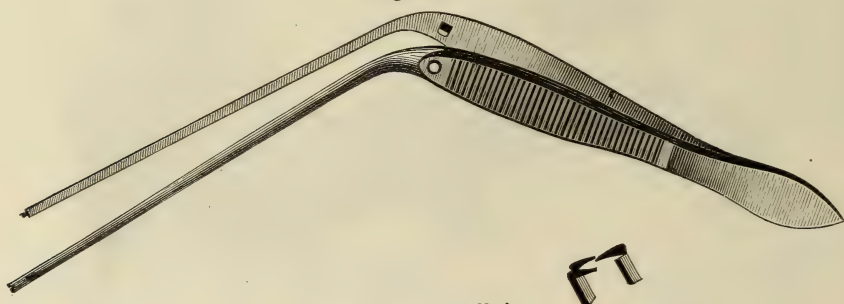
Forehead-mirror in actual use.

neighboring house, generally affords sufficient illumination for all ordinary purposes. If artificial light be used, it should be placed somewhat above the level of the patient's head, and a short distance to the right or to the left of a line drawn through the heads of the patient and the surgeon who is making the examination. At first, considerable difficulty will be experienced in securing a steady and good illumination of the deeper parts of the auditory canal, but with practice will come comparative ease in overcoming these difficulties. In this connection I wish to call attention to an important rule, viz., that in his efforts to cause the rays of light to fall upon the patient's ear, the physician should not depend upon the motions of his neck for the attainment of this object. After he has once placed his head in the position which is best adapted to the purpose of directly looking into the ear, he should keep it in that position, and the satisfactory illumination of the parts should be effected wholly by movements of the mirror proper, through the medium of its ball-and-socket joint attachment to the forehead-plate. A strict observance of this rule will greatly facilitate the task—by no means always an easy one—of obtaining a good view of the deeper parts of the auditory canal.

In making the actual examination, we must not forget one or two points of practical importance. In the first place, in the adult, the outer third of the auditory canal, the cartilaginous portion, usually forms an obtuse angle with the inner portion of the canal. To render the meatus straight throughout its entire length, we need only to pull the auricle slightly upward and backward. In infants, we may find it necessary to pull the auricle rather outward—away from the skull—and downward, in order to attain the same object. In the next place, if we wish to avoid the danger of wounding the

walls of the meatus, we should keep our eyes directed upon the parts illuminated at the bottom of the speculum, which is being gradually pushed, by a sort of boring motion, farther and farther into the canal. It is not necessary to push the instrument beyond the point at which a good view of the membrana tympani can be obtained. If we meet with obstructions, in the shape of cerumen, hairs, scales of epidermis, pus, etc., we must remove these, and for this purpose we shall find certain instruments almost indispensable. To most persons the syringe will suggest itself as the proper instrument to employ for the removal of any such obstructions in the canal. Others will employ by preference delicately constructed angular forceps, with toothed ends (as shown, considerably magnified, in the cut), especially if the obstruction be of such a nature that it may readily be grasped between the blades of such an instrument. If the body be more firmly lodged, the curette, or a

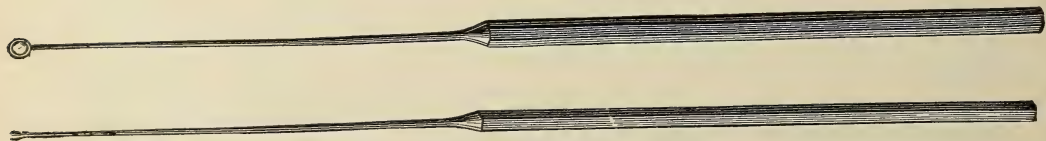
Fig. 947.



Angular forceps; full size.

slender silver probe, will be found very useful in loosening it from its attachments to the walls of the canal. Probes and curettes are important accessory instruments. In very many cases, simple inspection of the parts leads us to wholly erroneous conclusions with regard to the true state of things. I might enumerate a great variety of pathological conditions which even the most experienced specialist would be very likely to interpret incorrectly, if he were not allowed to use the probe as a means of confirming or correcting the judgment which he had arrived at by simple, unaided inspection. Both the probe and the curette, however, must be delicately constructed, or the surgeon will find them of comparatively little use, either as aids in making a

Figs. 948, 949.



Curette and slender probe.

correct diagnosis, or as substitutes for the forceps and syringe. The accompanying cuts show sufficiently well the size, shape, and dimensions of these two valuable instruments. The curette is made of polished steel, and the probe of soft silver, without alloy. In the drawing of the probe, both the knobbed end and the adjacent portion of the shank are thicker than they should be. The ring-shaped end of the curette has carefully rounded edges.

I never use this instrument as a scraper, but simply as a dissector, that is, as a means of loosening objects from their underlying attachments.

DISEASES AND INJURIES OF THE AURICLE.

ECZEMA.—The commonest affection to which the auricle is liable, is eczema. Among the children of the poorer classes it is an extremely frequent disease, and, on careful inquiry, it will generally be found that the cause is of a three-fold nature. In the first place, some direct source of irritation is necessary, and this will usually be found in the shape of a discharge from the external auditory canal. In the next place, in a properly fed, properly washed, and healthy child, the mere presence of a discharge from the meatus should not lead to more than a very limited eczema of the parts immediately bordering on the orifice of the canal. Hence we may safely assume, in cases of extensive eczematous inflammation of the auricle, that the child is neither properly bathed nor properly fed. As the result of feeding a child, of from one to five years of age, on pastry, tea, coffee, bananas, salt meats, etc., two things are apt to take place: the discharge from the ear assumes a highly irritating, in some instances positively corrosive, character; and the skin, not merely of the auricle, but also of other parts of the head, becomes so prone to inflammation that the slightest irritation from without suffices to develop a small furuncle, or an inflammation of a more extended character, like that observed in eczema. In adults these three factors—the presence of an irritating discharge from the ear, lack of cleanliness, and an improper diet—which are so generally the chief causes of the disease in children, are frequently lacking, and we are tempted to assume the existence of a constitutional vice or predisposition—by which I mean the circulation, in the blood, of certain elements which keep the skin in an irritable condition.

A mere redness and slight infiltration of the skin characterize the disease in its simplest form. When the affection becomes more pronounced, we shall find crusts or scabs covering the inflamed skin. In its most aggravated form, the auricle may present an almost continuous mass of scabs, and beneath them, in some spots, the skin will be found to be quite deeply ulcerated.

The *prognosis* of this affection is almost unqualifiedly favorable, though in elderly individuals it sometimes proves rebellious. The *treatment* should be both general and local. In children, the most important thing is to secure strict cleanliness, both with regard to the outside parts and with regard to the auditory canal. The child's diet should then be carefully regulated, and wholesome bread, butter, oatmeal, hominy, milk, fresh meat, and simply cooked vegetables, should be substituted for the unwholesome articles of diet which the child has previously been permitted to eat. In adults we may also find it desirable to prescribe a simpler diet, and abstinence from alcoholic beverages. In the majority of cases, moreover, we shall find that the patient does not take sufficient exercise in the open air, and we should be careful to direct attention to this point. It is also important to secure free and regular action of the bowels.

The local measures to be employed must vary according to the stage or condition in which we may find the eczema. Thus, for example, the auricle may be in a condition of such acute inflammation that cooling applications, or even local blood-letting by means of leeches, may be required. Such an acute eczema of the auricle is not often seen, and if the parts are merely red and swollen, we may prescribe at once the free use of an ointment consisting of oil of cade and vaseline, in the proportion of from two to five drops of the former to two drachms of the latter. The stronger preparations, such as

I used to prescribe a few years since, not infrequently increase the existing irritation; for this reason I now use habitually, and with equally good results, the weaker preparation mentioned above. It is important to keep this ointment constantly applied to the affected parts, by means of such dressings as will secure this result. All crusts and sheets of exfoliated epidermis must invariably be removed before the ointment is applied, and if there are any points at which actual ulceration has taken place, these must be touched with nitrate of silver, either in its crystalline state or in the form of a strong solution. In very many cases, a single, superficial application of the caustic suffices to remove, in from twenty-four to forty-eight hours, every trace of ulceration. Deep cauterization aggravates the evil.

As substitutes for the oil-of-cade mixture, either simple vaseline, or the benzoated oxide-of-zinc ointment, or Hebra's diachylon ointment, may be used.¹ Finally, whatever preparation we may decide to use, the necessity of carefully cleansing the affected skin, at least once a day, with warm water and Castile soap, or tar soap, must not be forgotten; and in drying the parts, care must be taken not to apply any more friction than is unavoidably necessary. Furthermore, it is a good plan to continue the local treatment for a few days after the parts present every appearance of having been restored to a normal condition.

SIMPLE DIFFUSE INFLAMMATION.—When hot poultices have been kept for too long a time in contact with the auricle, a diffuse and painful inflammation of the skin covering this part is excited. Precisely the same sort of inflammation is occasionally observed in the course of an acute attack of purulent inflammation of the middle ear, after the discharge has begun to escape by way of the external auditory canal. A differential diagnosis between such a simple diffuse inflammation and one of either eczematous or erysipelatos nature, is at times impossible. If it does not extend beyond the limits of the auricle, I think we may exclude erysipelas. If there are no evidences of eczema, either in the past history of the ear or in the presence of a desquamative eruption in the vicinity of the inflamed part, we may exclude that disease, and so, by exclusion, reach the diagnosis of simple, diffuse inflammation. A moderate rise in temperature is possible in all these conditions: hence the thermometer does not afford us material assistance in reaching a correct diagnosis.

Cooling applications constitute the chief and often the only remedy required.

PERICHONDRITIS (*Othæmatoma; Chondromalacosis; Chondromalacia; Hæmatoma Auris*).—A perichondritis of the auricle may develop spontaneously through degenerative disease of the cartilaginous framework, or it may owe its origin purely to outside influences, such as a blow, a burn, or a frost-bite. In the latter case, we are unquestionably dealing with a genuine inflammation of the fibrous nourishing membrane which closely envelops the cartilage of the auricle, and which sends vascular shoots through it at numerous points. In the former case, the pathological processes may be more appropriately designated by the term *chondromalacosis* than by that of perichondritis, inasmuch as softening and death of the cartilage precede and apparently give rise to the inflammatory changes in the overlying perichondrium.

As a rule, it is only after the disease has been in progress for some time, that the surgeon has an opportunity of studying its manifestations. The picture presented to his eye is very commonly that of a red and tense swell-

¹ For Hebra's formula, see Vol. III., page 58, note.

ing of the central and upper portions of the auricle. Fluctuation is easily recognized, and an incision affords escape to a yellowish, or pinkish, and rather sticky fluid. In some cases the tumor is almost black in color, and dark blood is evacuated by an incision. If exposure to excessive heat or excessive cold be the cause of the perichondritis, two or three isolated centres of disease may be found.

At a still later stage areas of ulceration may be seen, and frequently, in cases of chondromalacosis, there may be more or less thickening and deformity of the intervening parts. I have known the auricle to present, under such circumstances, every appearance of being cancerously affected.

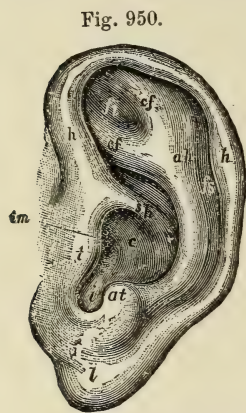
The *prognosis* in this class of cases has reference simply to the degree of deformity which is likely to result from the disease. In simple perichondritis the prognosis is favorable. If the abscess or collection of fluid is opened early and freely, very little, if any, deformity will be left after the parts have healed. In chondromalacosis, the degree of permanent deformity will depend chiefly upon the extent of cartilage destroyed, and only to a slight degree upon the inflammatory thickening of the perichondrium.

In the matter of *treatment*, we must be guided by the condition or stage in which we find the disease. If a tense, fluctuating swelling exists, we should incise it and evacuate the fluid contents of the tumor. Care must be taken not to make too small an incision, as our aim should be to place the diseased parts in such a condition that we may easily keep them thoroughly clean, and at the same time may with equal facility bring our remedial applications—nitrate of silver or tincture of iodine (either the simple or the compound tincture)—in contact with them. In some instances, pressure will promote the healing of the parts that have been kept separate for some time by fluid effusion. Cod-liver oil and a more generous diet will be found useful adjuncts in the treatment of many of these cases.

NEW GROWTHS.—Among the tumors of which the auricle may become the seat, the most common are undoubtedly the *fibroid* growths of the lobule. Their origin can very often be traced to the irritation produced by the wearing of an ear-ring. As a rule, they do not attain a size larger than that of a filbert or a hazel-nut, but in exceptional cases they have been known to grow to the size of a hen's egg. Negresses, it appears, are peculiarly liable to acquire fibroid growths of the lobule of the ear. The best plan of removing these tumors is to include the mass in a V-shaped incision, great care being taken to remove every trace of the growth, as otherwise, in a short time, a second one may be looked for at the same spot. Relapses, indeed, have repeatedly occurred, after the greatest care had been taken to remove every portion of tissue that seemed in the slightest degree likely to contain the germs of a new growth of the same nature. I remember a case of recurrent fibroid tumor of the auricle, in which the most careful search with the microscope failed to discover any cellular elements in any part of the mass. *Angeioma* and *epithelioma* of the auricle occur with nearly equal frequency, and both forms of tumor are much less common than the fibroma. In the early stage of an *epithelioma*, excision of the growth with a V-shaped portion of the periphery of the auricle, is the proper treatment to adopt; but at a later stage, when there are scattered foci of the disease—some of them too small to be distinguished by the naked eye—nothing short of complete amputation will suffice to arrest the advance of the malady. In cases of *angeioma*, Prof. Politzer recommends the employment of Paquelin's thermocautery. If the vascular tumor be of small size, he says that it may be destroyed at a single sitting, but that in the larger tumors the cauterization should be confined to a limited area, and that the procedure should then be repeated,

as often as may be found necessary, at intervals of five or six days. He also advises that, if any large artery (for example, the posterior auricular) be found acting as a feeder to the growth, it should be tied percutaneously. The danger of hemorrhage, after the use of the cautery, must also be constantly borne in mind. According to the same author, ligature of the carotid should not be resorted to until after the repeated use of the cautery has demonstrated clearly that the tumor cannot be destroyed by its employment. Successful results following ligature of the carotid have been obtained by Dupuytren, Mussey, and Weinlechner. Syphilitic *gummata* are sometimes observed on the auricle. Genuine *fatty tumors*, *horn-like growths* (*cornu humanum*), and the various forms of *sarcoma*, are quite rare.

CONTUSIONS AND WOUNDS OF THE AURICLE.—Serious wounds and other injuries of the auricle are not as common, at least in our large cities, as one would be led to expect from the exposed position of this part of the body. *Contusions* are quite frequently observed, but they generally require no special treatment beyond the employment of the simple measures which tend to allay inflammation. In the few cases in which the damage done has been sufficiently serious to set up a perichondritis, the treatment described as appropriate for that condition is the proper one to pursue.



Auricle (after Urbantschitsch).

ah, Antihelix; *at*, Antitragus; *c*, Concha (fossa conchæ); *cf*, Crura furcata; *fi*, Fossa intercruralis; *fs*, Fossa scaphoidea; *h*, Helix; *i*, Incisura intertragica; *im*, Introitus meatus audit. extern.; *l*, Lobulus; *sh*, Spina (crista) helicis; *t*, Tragus.

Wounds made with any kind of cutting instrument, are apt to result in a separation of a part of the auricle from the rest of the organ. This separation may be complete or incomplete. If it be incomplete, the opposite raw edges should be brought into exact coaptation, and held in that position either by sutures or by a network of cotton fibres over which collodion is freely applied. I remember an instance in which the cut extended through the entire thickness of the auricle, from the fossa conchæ, in the immediate neighborhood of the orifice of the external auditory canal, to the outer edge of the helix (see Fig. 950). The patient was intoxicated when the accident occurred, and remained in bed for three or four days without doing anything for the ear. By that time I found the raw edges of the wound granulating and bathed in pus. Nevertheless, very good results were obtained by simply bringing the raw edges carefully together and keeping them in position by means of cotton fibres and collodion. If the separation be complete, one part falling to the ground, union may still be expected to take place, provided that the severed fragment of the ear be carefully cleansed, and, as soon as possible, placed firmly in the position in which it belongs. To favor healing as much as possible, a covering of fine cotton or wool should surround the auricle, and thereby maintain the temperature of the separated fragment at a proper point. Triquet¹ mentions two well-authenticated instances of restoration of vitality in a severed portion of the auricle, and Schwabach² says that this successful result is often obtained after student-duels, in which a part of the auricle has been cut off by the sword.

The condition known as *cleft lobule* (due to wearing heavy ear-rings) is of

¹ *Traité pratique des maladies de l'oreille*. Paris, 1857.

² *Eulenburg, Real-Encyclopädie*. 1882.

common occurrence. The treatment consists in cutting away the opposite, cicatrized skin-surfaces, and then stitching the parts together as accurately as possible.

DEFORMITIES OF THE AURICLE.—Autoplastic operations have been performed for the relief of various defects and deformities of the auricle. The excision of a V-shaped piece will sometimes prove successful in diminishing the prominence of an abnormally large auricle, but I know of no means of giving firmness to a drooping auricle—one which lacks a properly developed cartilaginous framework—unless it be by causing its posterior surface to unite with the adjacent outer surface of the head.

FROST-BITE.—The auricle, by reason of its exposed position, is very apt to suffer from the effects of extreme cold. At first the cold produces contraction of the bloodvessels of the skin, but paralysis of their muscular elements soon follows, and the ear then presents a red or even purplish appearance, and is likely to be somewhat swollen. If actual freezing takes place, the ear assumes a whitish appearance, and may even, under the influence of prolonged cold, become brittle. Under favorable circumstances the frozen auricle (usually only its upper portion) may gradually resume its natural condition, though very commonly a certain degree of paresis of the bloodvessels remains, causing permanent redness of the affected part. The best method of thawing out a frozen ear is to rub it with snow at first, and then afterward with cold water. This must be done gently, as there is danger of breaking the frozen organ. When the circulation seems to have been re-established, tepid water may be used instead of cold. These procedures must be carried on either out-of-doors or in a cold room, the aim being to restore the frozen part very gradually to its proper temperature. In unfavorable cases—those, for example, in which the ear has been allowed to remain for too long a time in a frozen condition, or in which no precautions have been taken to secure its gradual restoration to a normal temperature—inflammation sets in, and, according to its severity, we may have as a final result either gangrene and sloughing away of the part affected, or a perichondritis, presenting the picture of a well-marked othæmatoma. The treatment required for the first of these conditions is amputation of the gangrenous portion; that required for the perichondritis has been already set forth on a preceding page.

As one of the sequelæ requiring surgical interference, I may mention the persistence of small, deeply excavated, sluggish ulcers, covered with hard, dry crusts. The favorite seat of these ulcers is on the upper part of the helix, or occasionally on the antihelix (see Fig. 950). It is not an easy matter to effect a genuine healing of these sores. The plan which I have found the most successful is this. After removing the crust, pare away with small, curved scissors, the bluish, undermined skin which surrounds the ulcer. Then either scrape the fibrous or cartilaginous floor of the ulcer with the point of the knife, or touch it lightly with nitric acid. Next fill the excavation with a pledget of cotton saturated with the compound tincture of iodine. Finally, as a means of holding the pledget in place, and of excluding the air, spread a few fibres of cotton like a network over the ulcerated area, and saturate the whole with collodion. Three or four days afterward, when the dressings are found to be loose, remove them, and re-apply cotton saturated with the compound tincture of iodine. By this mode of procedure, I have in several cases succeeded in permanently healing the chronic ulcers resulting from frost-bite.

BURNS.—Severe burns of the auricle present either the picture of a decided perichondritis, or that of a localized death or gangrene, and nothing further

need be said on the subject in this place. In the milder cases, the pain and soreness may be greatly mitigated by the local application of carbolated oil (3ij of carbolic acid to 3iij of olive oil) or carbolated vaseline. Cooling applications also afford relief.

DISEASES AND INJURIES OF THE EXTERNAL AUDITORY CANAL.

IMPACTED CERUMEN.—Of all the affections of the external auditory canal, impaction of cerumen is by far the most common. This condition is apt to be developed without any special symptoms. The accumulation of cerumen takes place so gradually that the patient rarely suspects what is occurring, until he suddenly becomes more or less deaf in the affected ear, and experiences a sense of fulness on that side of the head. Sudden alternations between good and defective hearing are among the most marked symptoms of this condition.

When the affected ear is examined with the speculum and reflected light, a black or dark brown mass will be found filling the canal, and obstructing the view of the deeper parts of the ear. As impacted cerumen is very apt to be associated with catarrhal inflammation of the middle ear, it will be found desirable not to express an opinion, either with regard to the nature of the ailment or with regard to the prognosis, until the auditory canal has been cleared of all obstructions.

The question of *treatment* resolves itself practically into the question, how can the obstructing mass be removed most thoroughly, quickly, and pleasantly? In my opinion, the instrumental method of removing impacted cerumen is, in the majority of cases, the most effective and at the same time the pleasantest way, both for the patient and for the physician, of accomplishing the desired object. I must confess, however, that a certain degree of manual dexterity is absolutely essential to the proper performance of the operation. It is also probably true that, among the great body of medical practitioners, only a small minority possesses the requisite skill in the handling of delicate instruments. While therefore the removal of impacted cerumen by means of the syringe may seem to be a clumsy and oftentimes ineffectual method of attaining the object desired, no better method, adapted to general use, has yet been devised.

One of the chief reasons why syringing so often fails to wash out the mass of impacted cerumen, is this: the force of the current is spent upon the broad surface of the outer end of the plug, and tends therefore rather to drive it farther inward. The most effective plan is to direct the stream against one edge (preferably the upper edge) of the mass, in the hope of washing out a channel between the main body of the plug and the upper wall of the meatus. As soon as this has been accomplished, it will be found that the current begins to exert a *vis a tergo* upon a portion of the mass, and soon brings away fragments of considerable size.

If simple syringing with lukewarm water fails, we may employ some chemical reagent for the purpose of softening the cerumen and loosening its attachments to the walls of the canal. Bicarbonate of sodium, for example, may be used to advantage as a solvent. A few drops of a strong solution of this salt should be dropped into the meatus (the patient's head being turned well over toward the opposite side), and should be allowed to remain there for at least twenty minutes. If syringing then fails to bring away the ceruminous mass, the soda solution should be introduced a second time, and even a third, if necessary.

In the instrumental method of removing impacted cerumen, the aim is to loosen the attachments of the impacted mass by means of suitable instruments.

These may either be introduced directly into the substance of the mass, for the purpose of breaking it into fragments, or they may be passed flatwise between it and the walls of the meatus, with the view of dissecting it out as a whole, or in larger pieces. For this latter purpose, the curette will be found a most excellent instrument. Angular forceps, of delicate construction, can also scarcely be dispensed with in removing the loosened mass or its component parts. As we approach the membrana tympani, in our mining operations, the slender silver probe will be found to be of great service, as it may, with care, be employed in loosening the inner end of the ceruminous mass from its attachments to the drum-membrane, or to the anterior inferior *cul-de-sac* of the meatus. In conclusion, let me remind the reader that manipulations of this kind should not be indulged in, unless the operator possess delicacy of touch, a thorough knowledge of the topographical anatomy of the auditory canal, and properly constructed instruments.

It sometimes happens, in these cases of impacted cerumen, that a furuncle develops in the obstructed meatus, or that an acute inflammation is set up in the adjacent middle ear. In the presence of such a complication, the question arises, shall we allow the intercurrent inflammation to run its course, before we make the attempt to remove the impacted cerumen, or shall we undertake the latter operation without further delay? The pain attending either of the two combinations mentioned, is apt to be very severe, and the inflammation is generally more extensive and of a more serious character than when the auditory canal is free from obstructions. If, therefore, we can, by any means at our command, remove these obstructions at once, it is clear that this is the proper course to pursue. If the orifice of the canal is closed, through oedematous swelling of the soft parts, it will be found comparatively easy to dilate it gradually by means of Wilde's specula, or by the aid of conical mops of cotton, wound firmly around the end of a probe or cotton-holder, and smeared with vaseline. As soon as the ceruminous mass has been exposed to view, we should proceed in precisely the same manner as if the case were one of a simple nature.

FURUNCLES, OR BOILS.—The external auditory canal seems to possess a special predisposition to furuncular inflammation. Our knowledge of the causes which give rise to the disease is very scanty. An irritating discharge from the middle ear, or from the deeper parts of the meatus (as, for example, in eczema), very often leads to the formation of furuncles in the outer or cartilaginous portion of the canal. It has also been observed that the disease is often encountered in persons whose general health is not quite up to the proper standard.

Furuncles usually develop gradually. The patient first notices a little pain in the region of the ear, and, on pressing with his finger upon the parts, finds that they are slightly tender. Gradually the pain increases in severity, and the ear feels full and heavy. Deafness is not observed until the tumor reaches such a size as to close the meatus at the point involved. The motions of the jaw are apt to cause pain, and in some cases there is well-marked oedema in the neighborhood of the affected ear. Rupture of the abscess may take place spontaneously as early as on the second day, but as a rule we must not look for this event before the third or fourth day.

The *prognosis* is decidedly favorable. The disease shows no tendency to extend inward, in the direction of the middle ear, and it is only in quite rare cases that the abscess, instead of breaking into the external auditory canal, burrows downward and forward in the direction of the parotid gland, or backward and downward in the direction of the soft parts lying below the mastoid process.

Treatment.—If it be admitted that neither the patient's life nor his hearing power is threatened, the chief indication will clearly be to relieve his suffering. It is a disputed point how this may best be accomplished. Some of the highest authorities unhesitatingly advise the early employment of the knife. My own experience, however, leads me to adopt the rule laid down by Wilde: "As soon as we believe matter has formed and come some way to the surface, but not till then, we should make an incision." I prefer, as a rule, to wait and let the abscess open by natural processes; and, as a means of hastening these, and also for the purpose of mitigating the patient's suffering in the mean time, I am in the habit of prescribing hot poultices. These should be of sufficient size to cover the entire region of the ear (say 5 or 6 inches square), and they should be renewed at frequent intervals. While the flaxseed-meal poultice is perhaps the best that can be used for this purpose, there are various substitutes which will be found to answer almost equally well: for example, a rubber-bag filled with hot water, a flannel or muslin pillow filled with dried hops and heated in the oven or in front of a hot open-grate fire, hot bran bags, a large sponge or several thicknesses of flannel wrung out of hot water, and so on.

I have very little faith in the local use of anodynes, and the introduction of glycerine, sweet-oil, or almond-oil, commends itself still less to my judgment. Glycerine is by no means a bland and soothing fluid, and the oils may furnish a nidus for the subsequent development of the *penicilium glaucum*, or some other variety of fungous growth, which the surgeon may find it difficult to dislodge. Vaseline, on the other hand, may be used with impunity in the ear.

Local blood-letting by means of leeches is very apt to fail in this form of disease, and I do not often resort to its use if I am sure of my diagnosis. In acute affections of the middle ear it is a much more valuable remedy.

If the knife be employed, the best pattern for this special purpose is a curved, sharp-pointed bistoury. If the swelling is well defined, the incision should be made through the centre of it, the point of the knife being carried from within outward. The operation should be performed under illumination from the forehead-mirror, and the incision should be made of such a length and depth as will afford a free exit to the pus. If the swelling is not well defined, my plan is to introduce a cotton-holder, well protected with cotton, into the swollen canal, and then to exert pressure in different directions. The region of greatest tenderness is that into which I make the incision. It is well to have at hand a large sponge and a basin filled with hot water. Immediately after the incision has been made, the hot and moist sponge should be held against the ear, for the purpose of quieting the pain, which for a few minutes is generally very acute. When the pain subsides, dry warmth may be substituted for the hot and moist application. The only objection to the prolonged use of moist heat under these circumstances is, that it favors the development of granulation-tissue in the wound, and is also apt to set up a painful inflammation of the auricle.

DIFFUSE INFLAMMATION.—Under the head of "diffuse inflammation of the external auditory canal," may be grouped the different pathological conditions to which the names "otitis externa diffusa," "periostitis," "eczema," "desquamative inflammation," and "otomycosis," or "parasitic disease of the external auditory canal," are commonly applied. It is not always easy to separate these different conditions, and to apply to them their proper distinguishing terms. In fact, it is only in a few typical cases that a distinct line of separation can be drawn. Furthermore, no great scientific or practical gain

is effected by the establishment of these subdivisions, and I may therefore be allowed to include all under the single head of diffuse inflammation.

A simple diffuse inflammation of the osseous portion of the meatus externus, may be set up by the presence of some irritating substance or fluid in the canal. For example, salt water may produce such an inflammation; and so may the irritating discharge from an inflamed middle ear. Among the internal or constitutional causes may be mentioned a predisposition to eczema (rheumatic? gouty?). An inflammation of the medullary spaces or of the air-cells of the surrounding bone, may give rise secondarily to a diffuse otitis externa. Direct violence is also not a rare cause of this form of disease.

The physical characteristics of a diffuse inflammation of the external auditory canal are, at first, a general redness and swelling of the osseous portion. The membrana tympani almost invariably participates in the inflammation, though sometimes only to a very slight degree. At a later stage of the affection, an exudation of a thin, serous fluid will be found to have taken place from these red and swollen surfaces, and at a still later period the discharge will be found to contain small white flakes, or even large white sheets, representing the cast-off, uppermost layers of epithelium. Eventually, ulceration may take place.

In those cases in which a vegetable parasitic growth develops in the inflamed meatus, this phenomenon, it seems to me, should not be considered in the light of a primary and independent disease, but rather as an accidental complication. The moisture supplied by the inflammatory exudation, the absence of a current which might wash away the germs, the presence of decomposing organic matters in the secretion, and probably also the darkness, furnish conditions which are favorable to the further development and multiplication of the vegetable germs which at all times fill the air, and which must therefore at all times be in the cavity of the external auditory canal. The appearance presented to the eye, in a typical case, is that of a meatus thinly or thickly covered with a fuzzy, white material which looks very much like cotton-wool. Black specks (*aspergillus nigricans*) are often scattered over the white ground, and sometimes this variety of the fungus predominates over the white or yellow variety.

The subjective symptoms of an otitis externa diffusa are, first, a sense of fulness in the affected ear, rarely amounting to actual pain; second, more or less diminution of the power of hearing; and, third, an itching sensation in the canal. In those cases which seem to be distinctively eczematous in character, this last symptom is sometimes extremely distressing.

The red, swollen, and perhaps moist condition of the parts, enables the observer to say positively that a diffuse inflammation of the external auditory canal exists, but it is not so easy a matter to determine whether this inflammation is primary in its nature, or merely secondary to an affection of the middle ear. We must test the hearing, examine the condition of the naso-pharyngeal mucous membrane, and ascertain, by auscultation during the act of inflation, the condition of the middle ear and Eustachian tube. If there is comparatively little disturbance of the hearing, if there is no evidence of an acute naso-pharyngeal catarrh, and if the air enters the tympanic cavity freely and without *râles* or crackling sounds, we are fairly justified in pronouncing the disease an acute, primary, diffuse inflammation of the external auditory canal.

The presence of *aspergillus* can only be determined positively by placing some of the suspected products under the microscope, and demonstrating the presence of the stalks, and perhaps also of the fruit, of the parasitic plant.

The different forms of diffuse inflammation of the auditory canal have very little tendency to damage the hearing, and apparently none whatever to

spread toward the middle ear or mastoid cells. By direct extension, they may excite a subacute mastoid periostitis. They are very apt also to occasion, or to be associated with, furuncles of the cartilaginous portion of the canal. In the acute cases, the prospects of an early and complete cure are good; in the chronic ones, our prognosis must be guarded, as the disease is, at times exceedingly stubborn, and relapses are very common.

The *treatment* must vary according to the stage or condition in which the disease happens to be. If the parts are simply red and swollen, and have not yet begun to secrete, a small blister over the mastoid process may be found sufficient to check the further progress of the disease. If the walls of the canal are already moistened by secretion, nitrate of silver in solution is to be employed. Before the solution is instilled into the meatus, it is very important to clean the inflamed parts thoroughly, so that they may be exposed to the full action of the remedy. The physician should therefore carry out this part of the treatment himself. Before the solution is introduced into the canal, the syringe and a vessel of warm water should be placed within easy reach. After the solution has been dropped into the canal, the physician should wait until the patient experiences a distinct sensation of warmth, pain, or throbbing in the ear. I always request the patient beforehand to direct his attention to the ear, and to inform me as soon as he perceives either of the sensations just mentioned. With a solution of from forty to sixty grains to the ounce, the sensation of warmth will generally not be felt by the patient until after the lapse of three or four minutes; with a solution of double that strength, the sensation is usually experienced much sooner. As soon as decided warmth, throbbing, or pain is felt by the patient, the remedy should be washed out of the canal by means of the syringe and tepid water. The walls of the meatus must then be dried carefully by means of the cotton-holder armed with absorbent cotton, and when properly dried they should be anointed with simple vaseline, or with vaseline to which a little oil of cade has been added. Very often a single such slight cauterization of the canal suffices to arrest the disease. In other cases two or three repetitions will be found necessary. These should be made at intervals of two or three days, and if the discharge from the ear is active, the patient should be instructed to wash out the canal with the syringe or douche once or twice a day. Otherwise the ear may be left alone from one visit to the next.

In the more distinctively desquamative cases, the treatment must be slightly modified. In the first place, a thorough removal of the firmly attached laminae of dead skin can scarcely be effected without the aid of the curette. This instrument, inserted flatwise between the dead and the living skin, may be used very effectively in dissecting off the former. The forceps then comes into play, or, if it be preferred, the syringe may be used for the purpose of removing the fragments or sheets of dead skin that have been separated from their attachments. Lately I have occasionally used liquid potassa soap in freeing the canal from these masses, and have found it very efficacious. When the walls of the canal have thus been carefully freed from all foreign matters, and, as it were, laid bare, we may proceed to the instillation of the silver solution. Furthermore, in this class of cases, it is important that the patient should keep the auditory canal, throughout its entire length, well anointed with the oil of cade and vaseline mixture, or with simple "cuticura."¹ At least twice a day he should make these applications to the canal.

¹ "Cuticura" belongs to the class of patent medicines, and bears a strong resemblance to vaseline. It differs from the latter, however, in one very important respect: it retains its semi-

ULCERS, POLYPOID GROWTHS, AND BONE-CARIES.—In the great majority of cases, the pathological conditions enumerated in the above title are encountered only as secondary phenomena, dependent upon a primary inflammation of the middle ear. In a few cases, however, they present all the appearances of being purely independent affections. If the true history were known in each such instance, it would probably be found that the primary affection had healed, leaving the secondary pathological process as the only evidence of active disease.

Cases of this kind are by no means common. They are interesting as pathological curiosities; but, as they do not differ, in any important respect, from the same lesions of a clearly secondary nature, I may be allowed to omit any further mention of them in this place.

SYPHILITIC ULCERS AND CONDYLOMATA.—Well-marked syphilitic lesions, such as ulcers, gummy spots or tumors, and papillary growths, are rarely seen in the external auditory canal. They are to be treated in precisely the same manner as these lesions in other parts of the body are usually treated, viz., by the internal administration of some mercurial preparation, or iodide of potassium, and locally by cauterization or excision.

FOREIGN BODIES IN THE AUDITORY MEATUS.—Under this heading are included all objects, or living organisms, which find an entrance into the external auditory canal from without, and not those which have developed in that cavity, or originally formed a part of its walls. They consist usually of such articles as a child is in the habit of playing with; as, for example, glass beads, small pebbles, bits of slate pencil, peas, beans of different varieties, cherry and prune pits, etc. Insects and bugs of various kinds also sometimes find their way into the meatus.

As a rule, the foreign body causes very little, if any, discomfort, and the patient is usually brought to the physician's office, more on account of the fear, on the part of the parents, that damage may be done to the ear if the foreign body be allowed to remain, than on account of pain or any marked impairment of the hearing observable at the time. When pain is a noticeable feature of the case, it will usually be found, on inquiry, that unskilled attempts have been made—in some instances by friends, in others, I regret to say, by medical men—to extract the foreign body. Cases have even been known in which persistent and violent attempts were made to extract a foreign body whose presence in the ear was purely imaginary.

It is, therefore, the physician's first duty, when consulted about a case of foreign body in the ear, to ascertain by direct inspection whether the object in question really is, or is not, present in the external auditory canal. When he has seen the foreign body, he should proceed to ascertain, by careful exploration with the curette or the slender middle-ear probe, whether it lies loosely, or is firmly impacted in the canal. The anterior *cul-de-sac*, which is situated between the membrana tympani and the anterior inferior wall of the meatus, is sometimes quite a deep recess, and may then readily harbor a small foreign body so perfectly that simple inspection will fail to discover the fact of its presence in the canal. If we have reason, therefore, to believe

solid, ointment-like consistence at the ordinary temperature of the human body, whereas vaseline at the same temperature speedily becomes almost as fluid as water. The composition of cuticula is unknown to me, but I have now used it for more than a year in cases of inflammation (eczematous or otherwise) of the external auditory canal, and can speak with confidence of its beneficial effects. I do not believe that its curative powers reside in anything that is peculiar to the preparation as a drug or chemical compound; they are due entirely, I believe, to the prolonged protection which it is capable of affording against the injurious effects of exposure to the air.

that the foreign body may be concealed in this pocket, we must bend the end of the middle-ear probe slightly, pass it gently down to the inner end of the canal, and then sweep the tip of the instrument cautiously along the bottom of the *cul-de-sac*, in order to bring the foreign body into view, if it be lodged in that locality. Again, I suppose I must repeat the caution, that only those who are able to see the *membrana tympani* distinctly, and who at the same time possess the requisite degree of delicacy in their manipulations, have any right to attempt the removal of such a foreign body by means of probes or hooks. All others should rest satisfied with the comparatively safe method of syringing the ear which is believed to harbor the foreign body. In this connection I desire to make the remark, that a failure to bring to light an object that is supposed to be lodged in the external auditory canal, by means of syringing, affords but a very poor guarantee that the canal is free from the presence of any such foreign body. Furthermore, there are occasions when the employment of the syringe may do positive harm; as for instance, when the foreign body is a dried bean or pea, which, under the influence of moisture, may swell up to twice the size which it possessed in the dry state. In the case of larger foreign bodies, which are actually impacted in the meatus, instrumental interference, by means of long and slender hooks of different sizes, becomes almost a necessity. Under such circumstances syringing is reasonably sure to fail, and, if such proves to be the case, the physician should frankly confess his inability to extract the foreign body, and should obtain the assistance of an expert. If the patient is free from pain, and there are good reasons for believing that the foreign body is not exciting inflammation of the surrounding parts, it will be perfectly proper to postpone surgical interference for several days, or even weeks, if necessary. The reasons why the foreign body should be removed, are these. It may change its position and assume one in which it will press against the *membrana tympani*; in the event of an acute inflammation of the middle ear, it may prevent the free escape of the discharge from the drum-cavity, and thus favor the development of serious intracranial disease (abscess or simple meningitis); and, finally, its presence in the auditory canal is almost invariably a source of great anxiety to the parents, and its removal is therefore likely to produce correspondingly great satisfaction.

In removing a loosely-fitting foreign body from the auditory canal, no difficulty will be experienced in passing a bent slender probe, or a slender steel hook, by the side of the object, between it and the wall of the meatus, and then turning the instrument on its long axis in such a manner as to bring the bent part of the hook directly behind the body. By cautiously pulling upon the instrument we may then readily extract the foreign substance. In the case of a tightly fitting object, we should proceed in precisely the same manner. The task, however, will be found far more difficult, and we may find it necessary to re-adjust the hook several times, before we finally succeed in dislodging the foreign body. All these manipulations, it must be clearly understood, are to be made only when the auditory canal is perfectly illuminated, and while the operator is observing as closely as he can the direction in which his instrument is travelling, and the depth to which he has made it penetrate.

The after-treatment in the more serious cases should be essentially the same as that which is required in cases of acute inflammation of the external auditory canal or middle ear. In the simpler cases no after-treatment is necessary.

WOUNDS OF THE AUDITORY MEATUS.—Wounds involving only the external auditory canal are in my experience quite rare. They usually result from

the introduction, into the meatus, of some sharp-pointed object against which a blow is received. These lacerated wounds of the auditory canal, or rather of the cartilaginous portion of the canal, present only one feature of special interest: I refer to the persistent bleeding which so frequently characterizes them. This symptom is undoubtedly to be attributed to the fact that those bloodvessels which pierce the cartilaginous framework, as many of them do, are not capable of contracting and retracting beyond a very limited extent; their physical relations being essentially the same as those of the bloodvessels which traverse bony structures.

The question of treatment calls for no special remark.

NEW GROWTHS.—The commonest form of new growth in the external auditory canal is the *osteoma*. It is encountered both in the form of an exostosis and in that of a more diffuse hyperostosis. The latter variety is more frequent than the former. In many cases, the development of new bone is clearly dependent upon inflammatory disturbances in the skin of the osseous portion of the canal, which is at the same time a periosteum, but in others no satisfactory explanation of the cause can be given. On an examination of the meatus with the speculum and reflected light, the picture presented to the eye of the observer is either that of a smooth, but very much contracted canal, or of one from some portion of which a hemispherical, broad-based, and very smooth mass, or one with a more or less well-defined neck, projects. The necessity to operate upon an exostosis may arise, as it appears to me, only under two conditions—viz., when, by its encroachment upon the calibre of the meatus, the tumor seriously diminishes the power of hearing (the other ear being, at the same time, either totally or markedly deaf), or when, by its damming up a discharge from the middle ear, it threatens to superinduce serious disease of the brain or other adjacent organs. In the latter event, the establishment of a counter-opening in the mastoid process may be found an easier, and yet equally effective, means of affording an outlet for the pent-up matter.

Primary *carcinoma* of the external auditory canal is exceedingly rare, and furthermore, in the few published records of cases, it is not made wholly clear that the tumor did not develop primarily in some neighboring region.

Sarcoma is also very rare as a primary growth in this region of the ear.

Cysts, with fluid or semi-solid contents, are occasionally encountered in the auditory canal. Those with fluid contents in the vicinity of the drum-membrane are, I might almost say, always secondary to some affection of the middle ear. In some instances, however, the primary disease recedes so completely, that the cyst-like formation in the meatus gains proportionally in individuality, and may even be taken for a tumor of primary development. As the description of these secondary cysts belongs more properly under the heading of diseases of the middle ear, I will say nothing further on the subject in the present section.

METHODS OF EXAMINING THE MIDDLE EAR.

The cavity of the middle ear is open to direct inspection only when, through disease, a large portion of the drum-membrane has been destroyed. Under other circumstances, we are obliged to infer what the condition of this cavity is, from a variety of data, such as the degree of acuteness of the hearing, the appearances presented by the drum-membrane, both before and after air has been forced into the tympanum, the character of the sounds heard through an auscultation tube during the performance of this operation, the condition of the integuments covering the mastoid process, the state of the naso-pharyngeal

mucous membrane, the results obtained with the tuning-fork test, the subjective symptoms as described by the patient, etc. Of all these data, the most valuable is unquestionably the appearance presented by the *membrana tympani*. A perfectly normal condition of the tympanic mucous membrane, and a perfect condition of the function of hearing, are scarcely possible, unless the *membrana tympani* is subjected to the same degree of atmospheric pressure on both sides. To maintain such a condition of equilibrium between the inner and the outer atmospheric pressure, Nature has constructed the Eustachian tube, or the channel of communication between the middle ear and the throat, in such a way that the air can readily pass through it, to and from the cavity of the tympanum. When this channel becomes obstructed by mucus, or closed through the swollen state of its walls, the condition of equilibrium ceases to exist; for the air confined in the middle ear rapidly becomes rarefied through absorption, and, as a result, the greater pressure upon the outer surface of the drum-membrane forces it inward beyond the position which it occupied when pressure and counter-pressure were exactly equal. The degree of patency of the Eustachian tube may therefore be estimated with considerable accuracy by a careful inspection of the drum-membrane. A slight diminution in the perviousness of the tube to air, will show itself in a shortening of the triangular "bright spot," which should extend from the immediate neighborhood of the "umbo," or tip-end of the handle of the hammer, nearly to the periphery of the membrane; in a change in the outer surface of the membrane, which, instead of the form of a shallow cone, assumes that of a saucer, or segment of a hollow sphere; and, finally, in some cases, in an increased transparency of the membrane. Only a practised eye can note changes of such a very slight degree. In the more marked cases of tubal obstruction, the "bright spot" will be found indeed to be a mere spot in the central part of the membrane, in front of the "umbo;" the unnatural concavity of the membrane will be readily recognized by even an unpractised eye; and its transparency may be so great as to delude even an expert into the belief that he is looking directly into a middle ear which has been deprived of its *membrana tympani*. This peculiar transparency of the membrane may be lacking; and in that event our attention will probably be attracted by other equally striking changes in the relations of the parts. I refer to the marked prominence of the short process of the hammer, to the sunken condition of the soft parts (*membrana flaccida*) immediately surrounding this bony prominence, to the sharply-defined outlines of the posterior fold, to the fore-shortening of the handle of the hammer, and to its apparent nearness to and parallelism with the posterior margin of the *membrana tympani*.

Inspection of the *membrana tympani*, when illuminated by reflected light, reveals to us still other conditions of this membrane and of the adjacent tympanic cavity. Thus, for example, we may learn the degree of vascularity and œdematous infiltration of these parts, the amount of free fluid contained within the tympanum, the presence of an excessive quantity of air in the middle ear, and many other less important changes in the condition of nutrition of these parts. The value of inspection may be greatly enhanced, in many cases, by the employment of certain collateral procedures, such as inflation of the middle ear by either Valsalva's or Politzer's method, the inclination of the patient's head either backward or forward, the careful manipulation or exploration of the parts with a slender probe or curette, and the exhaustion of the air in the external auditory canal. This latter procedure is carried out by means of what is known as Siegle's pneumatic speculum. This instrument consists of a central cylindrical chamber, of either metal or hard rubber, to which is attached a flexible rubber tube about a foot in length. To one end of the chamber, which is a little over three cen-

timetres in diameter, a conical speculum is fitted; the opposite end is closed by a glass window placed at such an inclination to the axis of the cylinder, that the rays of light used for illuminating the drum-membrane may readily pass through it without any portion of them being reflected back to the eye of the observer. The free end of the speculum is sheathed with rubber tubing, and may therefore be made to fit air-tight into the auditory canal. When the instrument is in actual use, the observer, by holding the free end of the rubber tube in his mouth, has it in his power to condense or rarefy the air in the auditory canal, and, while doing so, to watch the effects of these procedures upon the drum-membrane and handle of the hammer.

The remaining methods of studying the condition of the middle ear, derive their value chiefly from the facts which may be learned by auscultation combined with the forcible introduction of air into this part, by way of the Eustachian tube. There are three such methods, viz., Valsalva's, Politzer's, and that by means of the Eustachian catheter.

In inflating the middle ear by *Valsalva's method*, the patient closes both nostrils by grasping the nose with the thumb and forefinger of one hand, shuts his mouth firmly, and then makes a strong expiratory effort. In this way he compresses the air in the pharyngeal and nasal cavities to such an extent that it seeks an outlet through the Eustachian tubes. If the effort is successful, the surgeon, who has previously established a communication between his own ear and that of the patient, by means of a flexible auscultation-tube, will hear a slight puff or thud, as the air enters the middle ear and distends the drum-membrane. Of the three methods at our command, this is the most unsatisfactory for the purposes of auscultation, but decidedly the best when we desire to watch the changes that may take place in the drum-membrane while air is being forced into the middle ear. For therapeutic purposes, on the other hand, it is decidedly inferior to either of the other two, chiefly because it is associated with an undesirable, if not dangerous, degree of venous congestion about the head and neck. In Valsalva's method the introduction of air into the middle ears is not facilitated by the act of swallowing, which is an essential feature of Politzer's plan.

Poltzer's method of inflating the middle ear is very little better, for auscultatory purposes, than that of Valsalva, unless the surgeon can avail himself of the services of an assistant. If he attempt to inflate and auscultate at the same time, he will find the task an extremely difficult one, at least in adult patients. In children, so little force is required to inflate the middle ear, that one can often perform both acts at the same time in a very satisfactory manner.

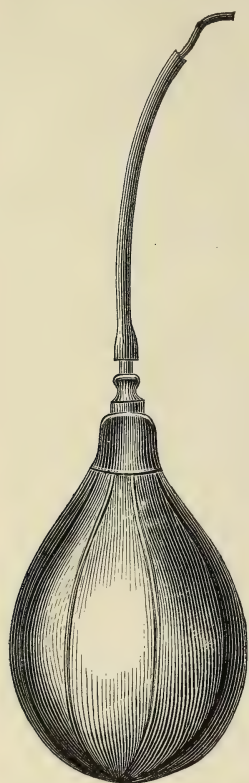
The apparatus which is usually employed in carrying out Politzer's method consists of a rubber bag, provided at one end with a hard-rubber nozzle; of a short piece of soft-rubber tubing, of rather small calibre, but of comparatively thick and unyielding walls; and lastly, of either a curved, cylindrical, or a bulbous, hard-rubber nose-piece. In adults, the curved, hard-rubber nose-piece, like that represented in the accompanying cut (Fig. 952), will be found entirely satisfactory in the majority of cases. In children under four or five years of age, in whom the nasal orifice is quite small and tender, a nose-piece consisting of a spherical or cone-shaped hard-rubber, or, still better, glass bulb, will usually be found preferable to the cylindrical one.

The mode of procedure, in Politzer's method, is as follows: The patient should take a little water—a few drops will suffice—into the mouth, and then, when the proper signal is given, he should swallow the water, while keeping his lips closed. The physician, on his part, should hold the rubber bag in his right hand, and, when the patient has taken the water into his mouth, he should introduce the nose-piece a distance of about half an inch

into his left nasal orifice, using, if necessary, his left hand to aid him in placing the instrument in its proper position on the floor of the nasal passage.

Fig. 951.

Fig. 952.



Politzer's apparatus.



Hard-rubber,
curved nose-
piece. Full
size.

As soon as he has accomplished this, he should at once compress the nostrils firmly over the rubber nose-piece, and give the patient the signal to swallow the water. The act of compressing the bag and forcing air into the nasal cavities should follow the signal almost instantly. With very deaf persons, a nod of the head or a nudge with the knee will serve as a signal; but in the majority of cases it is customary to give the command, Swallow! With children, it is often sufficient to simply instruct the child to keep the mouth tightly closed, or to inflate the cheeks, at the moment when we are ready to compress the rubber bag. These devices, however, and some others which lack of space will not permit me to describe, are inferior to the original Politzer's method in one important particular, viz., they do not take advantage of the great assistance afforded by the act of

swallowing in separating the lips of the tubal orifices, and thus rendering the tubes themselves more easily pervious to air, at least for the brief moment of time consumed by this act.

In this connection I should call attention to the fact that harm may sometimes be done to the ear by the careless or injudicious use of Politzer's method of inflation. The operation should never be resorted to until after both drum-membranes have been examined. The conditions which contraindicate sudden and forcible inflation of the middle ears, are these: a highly sunken drum-membrane, which may possibly also be

adherent to some of the deeper parts of the middle ear; a decidedly atrophied drum-membrane, or one in which a very thin cicatrix exists; and, finally, an acutely inflamed drum-membrane. In all of these conditions it is best to employ inflation, at first, in a cautious manner, or even—as, for instance, when there is active inflammation of the middle ear—to abstain entirely from using it.

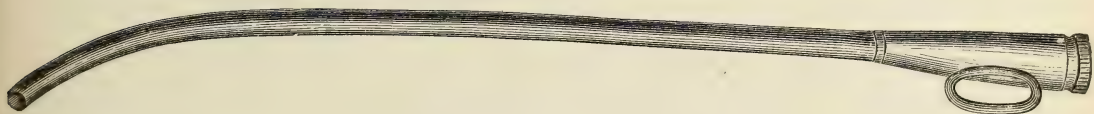
The third method of inflating the middle ear is that by means of the *Eustachian catheter*. When this instrument is used, the air passes through the Eustachian tube into the middle ear in a continuous current of one or two seconds' duration. This steadiness and long duration of the current afford the physician ample opportunity to listen deliberately to the character of the sounds which it produces. For purposes of diagnosis, therefore, this method possesses a decided superiority over the other two.

The instruments required for the operation of catheterizing the Eustachian tube, are a suitable catheter, either of hard rubber or of metal, an auscultation-tube, and a soft-rubber bag with a nozzle that can be applied to the mouth of the catheter in such a manner as to close it. A well-made hard-rubber catheter is an excellent instrument, and leaves very little to be desired. It is a very difficult matter, however, to obtain such a well-made catheter.

The calibre of the instrument is rarely as large as it should be, or else, if the calibre is sufficiently large, the total diameter of the instrument is so great that it can be used only in exceptional cases. A good, serviceable Eustachian catheter should have a calibre of about two and one-fourth, or two and one-half millimetres, and a total diameter of not more than three and one-half millimetres. This proportion of calibre to total diameter is scarcely attainable in an instrument made of hard rubber. The largest rubber catheter that can ordinarily be bought in the shops, measures nearly four and one-half millimetres in its total diameter, while its calibre measures only two millimetres. For the majority of nasal passages this instrument is too large, and yet its calibre is barely large enough to allow a current of air to be driven through the instrument into the Eustachian tube with the requisite degree of force. On the whole, therefore, the silver catheter, if made of coin metal and properly proportioned, will be found to give the greatest satisfaction. At the same time, it must not be forgotten that many of the silver catheters sold in the shops are even less serviceable than those made of hard rubber. The calibre is not one whit larger, in proportion to the total diameter, than that of the average hard-rubber catheter; and, furthermore, the edges of the beak of the instrument are often so sharp as to cause the patient pain, either during its passage through the nose, or while it lies in the mouth of the Eustachian tube.

With regard to the curve which a good Eustachian catheter should have, I may say that the one represented in the accompanying cut is that which I

Fig. 953.



Eustachian catheter, of silver; full size.

have found suited to the great majority of adult patients. Some of my colleagues use a straighter instrument, and others, one of even greater curvature; from which it is proper to draw the conclusion that the middle ear may be successfully inflated by variously curved catheters. To secure the most effective inflation, however, we should give the catheter such a curve that, when it is in position and air is forced through it, the direction of the escaping current may be the same as that of the Eustachian tube itself. The common error, as far as my observation goes, is to give the instrument a curve of too short a radius, which causes a large part of the force of the current of air to spend itself upon the upper wall of the Eustachian tube. In children from five to about twelve years of age, it will be found better to use a catheter that is even less curved than that represented in the cut; or one, at all events, in which the curve begins at a point considerably nearer the free end than it does in this instrument.

In my work on Diseases of the Ear, I have given a detailed description of the different steps of the procedure of introducing the Eustachian catheter, and I will essentially reproduce it here. The surgeon should sit directly facing the patient, and at his right hand, within easy reach, should be his rubber bag, auscultation-tube, and a bowl or goblet partially filled with water, and containing five or six catheters of different sizes and degrees of curvature. He should have his forehead-mirror in position, ready for use, as he may at the very beginning find it desirable to examine, under illumina-

tion by reflected light, the patient's anterior nares. Everything being in readiness, and the water having been shaken or blown out of the catheter, the operator should place the fingers of his left hand firmly upon the patient's forehead, and, with the end of his thumb, he should elevate as much as possible the end of the patient's nose—the object of the latter procedure being to straighten the entrance to the nasal passage, and in so far to facilitate the introduction of the catheter. This instrument should be held lightly by the surgeon, between the thumb and forefinger of his right hand, and at no time should force be used in overcoming any obstacles that may be encountered. Just within the nasal orifice, the floor of the nasal passage rises up in the form of a ridge, the inner or deeper side of which is more abrupt than the outer one. When the catheter is first introduced into the nasal orifice, its outer end should be at a somewhat lower level, though in some cases we may begin at once with the instrument in a nearly horizontal position. To pass it beyond the ridge, and engage it in the lower nasal passage, the surgeon must elevate the ring end of the instrument until it occupies a nearly horizontal position. It is at this stage of the operation that the beginner is very apt to make a mistake. Instead of passing the catheter along the floor of the nasal canal, he slips it over the upper surface of the inferior turbinated bone, and, on reaching the naso-pharyngeal space, wonders why his efforts to turn the instrument into the mouth of the Eustachian tube cause the patient such great distress. A glance at the illustrations of this region, in some good treatise on anatomy, will show how easy it is to make this mistake. It is only necessary to push the beak of the instrument a short distance beyond the summit of the ridge, and we shall find it slipping only too easily along the wrong channel. When the catheter has been pushed beyond the ridge, and is actually resting upon the inferior turbinated bone, the elevation of the ring end of the instrument will not correct the error unless the catheter be withdrawn a certain distance. In the first stage of the operation, therefore, it is important to hug the floor of the nasal passage with the beak of the catheter, at least until the instrument has passed beneath the inferior turbinated bone, and is well engaged in the lower channel. As already stated, it is better, from this point onward, to let the instrument find its own way. By this I mean that if the catheter encounters some obstacle, we should abandon the attempt to push it onward in a certain fixed manner—that is, with the beak always pointing downward and backward—and should rotate the instrument slowly, while keeping up a gentle pressure from behind, until we find a position in which it no longer encounters opposition, but yields to the pressure which tends to drive it farther inward toward the naso-pharynx.

As we wish the instrument, on first reaching the cavity, to lie with its beak turned directly downward, we should begin at once, after passing the obstacle referred to, to rotate the catheter back toward the desired position. If we fail in our efforts to overcome the obstacle encountered, we must either resort to an instrument of smaller diameter, or try to reach the Eustachian tube by way of the nasal passage of the opposite side. The latter course will usually be found the preferable one. When the catheter is in the naso-pharyngeal space, with its beak turned directly downward, we should first make sure of our bearings by pushing the instrument onward until we feel the resistance offered by the posterior pharyngeal wall. When the catheter is in this position, we know that if we rotate it far enough we shall carry the beak into what is known as Rosenmüller's fossa, a slight depression located just behind the mouth of the Eustachian tube. Hence, if we wish to introduce the instrument into the latter cavity, we must draw it out a distance of a quarter or three-eighths of an inch, and then rotate it through an arc of about one hundred and thirty-five degrees, or until a line drawn through the plane of the ring

attached to the catheter passes through the outer angle of the patient's eye. If we rotate the beak of the catheter first into Rosenmüller's fossa, and then draw it out a short distance, we can often feel the end of the instrument pass over the rounded eminence which constitutes the inner lip of the mouth of the Eustachian tube. As the distance of the tubal orifice from the posterior pharyngeal wall varies in different individuals, the method last described, of guiding our movements by aid of the sense of touch, rather than by rough estimates of distance, is the one to which most aurists, I think, give the preference. In some individuals, the landmark which I have just described is so feebly developed, or the surrounding parts are so swollen, that the operator feels doubtful whether he has reached the mouth of the tube or not. In such cases the Giampetro-Löwenberg method will be found useful. According to this method, the catheter is to be rotated toward the Eustachian tube of the opposite side, and when its beak occupies a horizontal position, as indicated by the metal ring, the instrument is to be drawn out until the resistance of the posterior edge of the nasal septum is encountered. The catheter is then to be rotated in the opposite direction, through an arc of at least one hundred and eighty degrees, into the mouth of the Eustachian tube which it is desired to reach. In all three methods, but especially in the one last described, the surgeon will do well to grasp the body of the catheter with the thumb and forefinger of his left hand before he performs the act of rotation with his right hand. In any event he will have to grasp it in this manner after the instrument finally reaches its proper position, as the right hand will be required for other purposes. The support thus afforded to the catheter is a very firm one, as the last three fingers of the left hand find a strong resting-place on the bridge of the patient's nose, or on the lower part of his forehead. As long as the operator's fingers press firmly against the patient's skull, he need have very little fear of the disturbing influence of a sudden motion of the patient's head upon the position of the catheter.

When the surgeon believes that the beak of the instrument is lying in the mouth of the Eustachian tube, he should give the patient one end of the auscultation-tube to place in the meatus of the corresponding ear, and should fix the other end tightly in his own auditory canal, preferably the left one. With his right hand he should then grasp the rubber bag (the ordinary Politzer's bag will answer well for this purpose) and apply the hard-rubber nozzle of the instrument to the mouth of the Eustachian catheter. If the latter instrument is in the right position, and the Eustachian tube is not unnaturally contracted, he will hear the air streaming as it were into his own ear. If the catheter, however, occupies a wrong position, he will probably still hear the air streaming out of the end of the instrument, but it will no longer seem to be escaping into his own ear; the sound will appear to be more distant and less distinct.

In withdrawing the catheter from the nasal cavities, no special precautions are necessary. The instrument is first to be rotated back to its original position, with the beak pointing downward, and then it is to be drawn out gently from the nose.

Great stress is laid, in some treatises on practical otology, on the danger of causing emphysema of the cellular tissue in various parts of the neck, but particularly in the region surrounding the entrance to the air-passages, in the course of the operation of forcing air into the middle ear by means of the Eustachian catheter. I must confess that I have never seen an instance of this accident, nor have I heard of its occurrence in the practice of any of my colleagues here in New York. I can easily understand, however, that the employment of a catheter with a sharp-edged beak, or the use of too much

force in getting the instrument into its proper position, might lacerate the mucous membrane at the mouth of the tube, and so open the way for the production of an emphysema of even wide extent.

DISEASES OF THE MIDDLE EAR.

NON-SUPPURATIVE INFLAMMATION OR SIMPLE CATARRH.—By the term “catarrh of the middle ear,” as used in this article, and very generally by American surgeons, is meant a type of inflammation of the mucous membrane of the Eustachian tube, tympanum, and communicating pneumatic spaces, which is characterized by redness, swelling, and increased secretion of the parts, and which stops short of ulceration and perforation of the membrana tympani. When the affection is of recent date, and subsides in the course of a few days or weeks, we speak of it as an “acute catarrh of the middle ear” (*otitis media catarrhalis acuta*). When the history given by the patient shows that the pathological process has been going on for months, and perhaps even years, we may properly designate the affection as a “chronic catarrh of the middle ear” (*otitis media catarrhalis chronica*).

An *acute catarrh of the middle ear* may manifest itself under different forms. For example, the inflammation may restrict itself almost entirely to the Eustachian tube, and the expression “Eustachian catarrh” is then very often employed. In comparatively rare instances, the inflammation displays a mild character in its course along the Eustachian and tympanic portions of the mucous membrane, and then spends its greatest force upon the mastoid portions; or the upper portions of the tympanic cavity may show evidences of an active inflammation of the mucous membrane, while the lower portions remain in almost a normal state. In fact, many cases of severe purulent inflammation of the middle ear begin, as far as I have been able to judge from simple inspection of the membrana tympani with reflected light, as a localized inflammation of the upper portions of the tympanic cavity. The prevailing type of an acute catarrh of the middle ear, however, is characterized by a more uniformly distributed congestion and swelling of the drum-membrane, and by more or less marked closure of the Eustachian tube. Sometimes both ears are equally affected, but as a rule the inflammation is much more active on one side than on the other.

An inflammation of the naso-pharyngeal mucous membrane almost invariably precedes this variety of aural disease, and the naso-pharyngeal inflammation in its turn owes its origin to exposure to cold, or to the specific influence of the poison of smallpox, scarlet fever, or measles. In a few cases, the ear disease owes its origin directly to the entrance of an irritating fluid into the tympanic cavity, by way of the Eustachian tube, or to the irritation caused by the presence of too hot or too cold fluid in the external auditory canal.

The *symptoms* are various, and all are not always present in one and the same case, or in one and the same ear. Pain in the affected region is the most prominent symptom. It is rarely severe, and in many cases is entirely absent. Pulsation is not often felt by the patient. If present, it usually indicates that an exudation of fluid has taken place in the tympanic cavity, or that the Eustachian tube is impervious to air. Subjective noises of varying intensity and character, and resonance of one's own voice in speaking, are common symptoms. More or less marked diminution of the hearing is always present. A sensation of fulness or weight in the affected ear, is sometimes mentioned as a prominent symptom. Numbness of the affected

side of the head is not a rare accompaniment of the disease, and I have known it to persist for a long time. In exceptional cases, deep pressure in front of the tragus causes pain, and the glands on the side of the neck, below the ear, are very apt to be tender and perceptibly swollen. The act of swallowing is at times accompanied by pain, or by a sense of soreness in the region of the Eustachian tube. In some cases the patient complains that loud sounds produce a painful sensation, not so much in the ear proper as in the sensorium. Certain musical tones, especially those of a comparatively high pitch, may also produce a peculiar fluttering or jarring sensation, which is felt directly in the ear, and which is very distressing. Double hearing even is observed in rare instances. Finally, in a certain proportion of the cases, free serum or mucus accumulates in the tympanic cavity, and its presence may then give rise to some very characteristic symptoms, such as a sense of something moving in the deeper parts of the ear when the head is moved, a crackling sound when the nose is blown, and a marked increase in the acuteness of the hearing when the head is held in a certain position—as a rule, that maintained by a person in the recumbent posture.

The *physical examination* follows next in order. Some impairment of the hearing of one or both ears will always be found, but it may be of very slight degree. The vibrations of the tuning-fork which rests upon the centre of the patient's forehead, will almost invariably be heard loudest in the ear most affected. I have, in a few instances, met with the reversed state of things, and have been puzzled to find a plausible explanation of the phenomenon. That given on page 682 is the only one that I can offer. We must remember, however, that while a temporary participation of the labyrinthine vessels in the inflammation, leading to diminished perceptive power of the auditory nerve of the side affected, will perhaps serve as an explanation for some of these cases; in others, it is quite possible that the phenomenon may be due to the existence, in the apparently well ear, of some changes in the structure or tension of the apparatus of hearing, of so slight a degree that we are unable to measure them, but yet sufficiently marked to produce the discrepancy referred to above, viz., that of referring the sound of the vibrating tuning-fork to the good ear. As a matter of course, the presence of a mass of cerumen or of a plug of cotton in the presumably well ear, will destroy the value of the tuning-fork test.

The drum-membrane of an ear which is the seat of an acute catarrhal inflammation of the middle ear, may be expected to show, in the earlier stages of the disease, evidences of congestion. The long process of the malleus, and the circular periphery of the membrane, are the regions in which the bloodvessels will be found gorged with blood. Sometimes the area of redness will involve the intervening parts of the drum-membrane, and occasionally even the adjacent cutaneous walls of the canal will show evidences of participation in the inflammation. The polished appearance, which is a marked feature of the normal *membrana tympani*, is soon succeeded by a dulness and roughness of the surface, attributable to an exudation of serum and lymphoid cells from the bloodvessels. In another class of cases, we shall find the lower part of the drum-membrane fairly normal in appearance, while the upper part, and particularly the thicker tissues constituting the posterior fold, show very decided evidences of active inflammation. In a third class, finally, the membrane, while retaining its polished surface, presents an appearance quite different from that observed in the normal drum-membrane: the tissues composing it look as if they had been soaked in oil, and the prevailing color is not the grayish slate-color of the normal membrane, but a dark purple, or even a dull greenish hue. On closer inspection, we shall find that we are looking at a very much sunken membrane, and that the

peculiar color is due to the reflection of light from the very red mucous membrane of the promontory. If air still remain in the drum cavity, the tint reflected will be reddish or purple, but if a yellowish, translucent serum be present in the cavity, it will be likely to impart a greenish hue to the color. In these cases, we may confidently assume that the Eustachian tube participates very decidedly in the pathological changes, and that its permeability to air is, for the time, suspended. If the tympanum contains partly air and partly fluid, we may see the outlines of bubbles through the membrana tympani, or a delicate line corresponding to the boundary of the fluid.

Our attention should next be directed to the condition of the naso-pharyngeal region. From the patient's own statements, we shall probably already have learned that the aural symptoms developed during an attack of "cold in the head," and on direct examination of the pharyngeal mucous membrane, we shall be likely still to find evidences of the disease in this locality, viz., redness, swelling, and perhaps increased secretion. If such evidences, however, are lacking, we must not allow ourselves to draw the inference that the region which is situated higher up, and which we cannot see unless we employ a rhinoscopic mirror, is likewise free from all inflammatory irritation. In fact, we may with great positiveness assume the very reverse of this, and that too, oftentimes, despite the patient's assurance that all symptoms of the "cold in the head" have entirely disappeared. This a point on which I desire to lay particular stress, for it is one that is very often overlooked, and yet it is the very one upon which the successful treatment of this class of cases hinges.

In well-marked cases, the course of the disease will cover a period of from two to five or six weeks. Under unfavorable conditions the irritation may persist for months, and may resist our best efforts to get the mastery over it. A complete or apparently complete return of the middle ear to a normal condition, may confidently be looked for in the great majority of cases. It is only in a few of them that the acute attack proves to be the beginning of the chronic form of the disease, with its attendant symptoms—permanent diminution of the power of hearing and distressing subjective noises.

Treatment.—As I have already said, the most important feature, in the treatment of this disease, is to try and restore the naso-pharyngeal mucous membrane to a healthy condition. In my hands, nitrate of silver has proved to be the remedy by far the most effective in accomplishing this object. It is certainly a disagreeable remedy, even when properly managed; and when applied in a careless manner, it is quite sure to produce nausea or headache, or at least a great increase, for a short time, in the amount of mucus secreted by the glands of the naso-pharyngeal region. If we are careful, however, to employ only as much of the solution as will suffice to thoroughly moisten the mucous membrane to which it is applied, we shall rarely meet with any of the disagreeable symptoms mentioned. If we are careless about taking these precautions, and introduce too large a quantity of the solution, the excess will find its way into the larynx, into the nasal passages, or down upon the upper surface of the roof of the tongue, and thus give rise to a great deal of unnecessary discomfort, if not to symptoms of a decidedly alarming character, such as spasm of the glottis. A rod, probe, or wire, bent near one end at a right angle, and armed with a mop of absorbent cotton, will be found a most useful instrument for the purpose of applying the remedial solution to the naso-pharyngeal cavity. The strength of the solution must vary according to the age of the patient, the activity of the catarrhal inflammation, and other minor circumstances. In a young child I usually begin with a ten-grain solution, and soon increase to one containing twenty, thirty, or even forty grains of nitrate of silver, in a fluidounce of water. In an adult I

always begin with a twenty-grain solution, and increase, if necessary, to one of double or treble that strength. In the majority of cases it is not necessary to use habitually anything stronger than a thirty-grain solution. I am not in the habit of making the applications oftener than once every other day, or three times a week; and if, by the end of the third or fourth week, I have not succeeded in allaying the major part of the naso-pharyngeal irritation, I advise the patient to take a rest of one, two, or three weeks, before I resume the applications to the affected region. If no improvement whatever results from the first series of applications, it is not at all likely that a continuance of the same treatment will prove any more successful. It is more than likely, in such a case, that adenoid vegetations are present, or that some similar condition of the vault of the pharynx exists.

In addition to these direct remedial applications, we must see to it that the patient is not indulging the habit of smoking to excess, or of imbibing frequently the stronger (undiluted) alcoholic drinks. Both of these habits tend unmistakably to promote congestion of the naso-pharyngeal mucous membrane.

The practice of injecting weak remedial solutions through the catheter into the middle ear—or at least into the Eustachian tube—is one which I have long ago abandoned, though I believe that it is still very commonly followed by European specialists. The good effects produced by the application of remedies to the naso-pharyngeal cavity are not by any means confined to that particular region; they extend promptly to the neighboring Eustachian tube, and even to the middle ear proper, and we may place sufficient confidence in this extension of a beneficial therapeutic influence, to justify us in abstaining from all direct interference with the deeper regions. I know that European authorities are all against me in this opinion, but my own experience, and that of at least some of my brother specialists, warrant me in maintaining it strongly.

While the treatment of the naso-pharyngeal disease often succeeds in restoring the middle ear to a normal condition without the aid of any other measures, it is better, as a rule, to employ systematically inflations by Politzer's method, in addition to the naso-pharyngeal treatment, just as soon as the ear has been free from pain for a period of two or three consecutive days. The beneficial effects of this procedure are to be attributed in part to pressure upon the swollen mucous membrane of the Eustachian tube and middle ear, in part to the restoration of that condition of equilibrium to which I have already made reference, in part to the actual expulsion of some of the mucus or muco-pus contained in the middle ear, and perhaps also in part to the breaking up of any fresh adhesions that may have formed between different parts of the membrana tympani, or chain of ossicles, and the neighboring walls of the cavity. Experience has shown that excellent results are obtained by resorting to Politzer's inflations only on alternate days; and it has been found, furthermore, that three or four successful inflations, at each visit or sitting, suffice. In a few cases we shall find it necessary to employ the catheter, in order to gain an entrance for the air into the middle ear; but in the great majority of instances we shall find no need of subjecting the patient to this very unpleasant operation.

In persons who are somewhat depressed in health, especially if they have passed the age of fifty, it is not an unusual experience to fail in our efforts to restore the affected ear to its normal condition, either in appearance or in function. The naso-pharyngeal mucous membrane seems to respond well enough to treatment, but the Eustachian tube and middle ear lag behind, and display very little recuperative power. Under these circumstances, I persevere in the treatment for three, four, or perhaps five weeks, using as adjuncts

counter-irritation behind the ear (tincture of iodine every night, or cantharidal collodion every fifth or sixth day), and even sometimes local blood-letting (one or two leeches in front of the tragus). If the affection still remains stubborn, and if the patient can afford to take such a trip, I urge the advantages of a decided change in climate, scene, and diet, for a period of a few weeks. This pleasant prescription has, in my experience, repeatedly accomplished what my local measures have been powerless to effect. The dryness afforded by a decidedly sandy soil, and the protection from strong winds conferred by pine forests, are two important features to be sought after in the selection of such a temporary place of residence. But if these peculiarities of soil and surroundings can only be obtained at the cost of considerable personal discomfort, such as is caused by a poor diet, uncomfortable living quarters, and an uncongenial social atmosphere, I think that a mere pleasure trip, in which the exhilarating effects of travel constitute the chief curative factor, should be given the preference.

This is the proper point at which to consider the question, how far our treatment should be modified when we find the middle ear filled with a serous or mucoid exudation. This state of things, which is commonly termed *otitis media serosa*, or *otitis media mucosa*, naturally suggests the propriety of incising the membrana tympani, and evacuating the fluid contents of the middle ear through the artificial opening thus established. The operation is not usually a difficult one, and the immediate results of evacuating the fluid are often brilliant, but, unfortunately, they are very apt to be of only short duration. The fluid returns; a fresh impetus is given by the incision to the tympanic irritation; and we find, after the lapse of a few days, that the patient is in precisely the same condition as that in which he was at the time when the operation was performed. At the present time I very rarely resort to paracentesis of the membrana tympani for the relief of the condition now under consideration; and my impression is, that the best authorities, at least in the United States, hold very nearly the same views that I do with regard to the efficacy of this procedure. The presence of serum or mucus in the drum-cavity is one of the legitimate phenomena of an acute, catarrhal inflammation of the middle ear, and calls for no material modification of the treatment commonly adopted in cases of that affection.

The operation of paracentesis of the membrana tympani will be described hereafter, under the head of Acute Purulent Inflammation of the Middle Ear.

The term *chronic catarrh of the middle ear* is very commonly applied to a variety of conditions, which are probably quite distinct from each other in their mode of origin and nature, but which are characterized by the same train of symptoms, viz., progressive deafness, subjective noises in the ears, and an intact drum-membrane. For purposes of convenience, we may roughly divide these cases into three groups. In the first, we may place those cases which are characterized by evidences of congestion and infiltration of the mucous membrane of the middle ear, associated with a similar condition of the naso-pharyngeal mucous membrane. *Chronic, hypertrophic, catarrhal inflammation of the middle ear* would be a proper expression to employ in designating these cases. The characteristic features of the second group of cases are these: a very transparent membrana tympani, revealing quite clearly the lower end of the long process of the anvil, the dark niche of the fenestra rotunda, and the intervening whitish region of the promontory; an apparently unobstructed Eustachian tube; and, finally, a perfectly smooth, or slightly ridged, pale, thin pharyngeal mucous membrane, traversed perhaps by two or three dilated, superficial veins. A process of atrophy and sclerosis will explain all of these appearances, and we may therefore designate the cases belonging to this

second group by the term *sclerosis of the mucous membrane of the middle ear*. Finally, we may place in the third group all those cases in which we are unable to discover any lesions of sufficient gravity to account for the marked impairment of the hearing. To explain the deafness in such cases, we are obliged to resort to mere guessing: there may be an anchylosis of the stapedio-vestibular joint, brought about by a rheumatic or other inflammation of the annular ligament, or of the tendon and sheath of the stapedius muscle; calcareous material may have been deposited in these structures, or in the secondary tympanic membrane at the round window, and thus an anchylosis may have been produced; an exostosis, or a more diffuse hyperostosis, may hamper the stirrup in its action, or may limit the excursions of the membrane at the round window; and, finally, the lesion may be located at some point in the course of the auditory nerve. All of these lesions have been found after death, but with our present knowledge we can only conjecture their existence during a patient's lifetime.

The *prognosis*, in chronic catarrh of the middle ear, is decidedly unfavorable. In the cases which belong to the first group, the patient is very apt to hear better at one time than at another, and by appropriate treatment we can sometimes improve the condition of the hearing to an appreciable degree. In cases belonging to the other two groups, however, and also in very many, perhaps the majority, of those belonging to the first, we cannot encourage the patient to hope for any improvement. On the other hand, we may make the statement that, in very many cases, the progressive quality of the disease is lacking: a certain degree of impairment of the hearing is reached, and then for years, perhaps for the remainder of one's life, no further diminution takes place.

If a more or less active naso-pharyngeal catarrh exists, with some congestion of the middle ear, the *treatment* appropriate for this condition must be adopted.¹ Some patients are much more anxious to be relieved of the distressing tinnitus that often accompanies this affection, than of the deafness. If there are sufficient grounds for the belief that a sluggish gastric digestion is promoting the naso-pharyngeal irritation, and secondarily the tinnitus, we may sometimes materially diminish the severity of this distressing symptom by prescribing dilute nitro-muriatic acid, in doses (three times a day, immediately after meals) of from three to ten drops, to be taken in a sufficient quantity of water. In a few cases, the bromides afford some relief, and the same is true of counter-irritation behind the ear. Active out-door exercise will also be found beneficial in some cases. Chronic tinnitus is, in the main, about as incurable as cirrhosis of the liver.

ACUTE PURULENT INFLAMMATION OF THE MIDDLE EAR.—This form of inflammation of the middle ear, like the catarrhal variety, usually owes its origin to an extension of the inflammation from the naso-pharyngeal space to the tympanic cavity, by way of the Eustachian tube. In scarlet fever, smallpox, syphilis, diphtheria, and perhaps typhoid fever and measles, the inflammation peculiar to these diseases may develop primarily in the middle ear, in the same manner as it does in the pharynx and naso-pharyngeal space. Exposure to cold is also a very common cause of the inflammation, and not a few cases owe their origin to bathing in salt water, some of which penetrates into the middle ear by way of the Eustachian tube. The nasal douche and the posterior nasal syringe sometimes act in the same way. The inflammation of the middle ear observed in cerebro-spinal meningitis may be due in some instances, possibly in all, to an extension of the disease from the cranial cavity

¹ See page 708.

to that of the middle ear. The same remark is probably true of those rare cases in which an otitis media acuta develops in consequence of an attack of sunstroke or heat-prostration. Finally, direct violence may be the exciting cause of the disease.

Symptoms.—In its early stages, an acute purulent inflammation of the middle ear is not distinguishable, in its subjective and objective phenomena, from the acute catarrhal variety. The pain, it is true, is apt to be more severe, and a point is soon reached at which the objective appearances show clearly that the disease is to be of the purulent variety. The drum-membrane either presents a dry, red, and tense appearance, or else all the tissues at the inner end of the external auditory canal appear to be soaked, and a small quantity of free exudation may be found on the lower wall of the canal. Beneath this white coating of soaked and loosened epithelium, which can generally be removed without difficulty, there will be found the red and swollen tissues of the inflamed drum-membrane. If the swelling is moderate in degree, the posterior half will probably be found in a bulging condition, but when the swelling is more marked we must not expect to find any recognizable bulging of the membrana tympani. If at this time a vent is not established artificially in the membrane, the continued pressure upon its inner surface will sooner or later cause one to form, and thus afford an outlet for the pent-up secretions; for the swelling of the parts around the tympanic orifice of the Eustachian tube prevents all escape of fluids by way of this channel. In such diseases as scarlet fever, diphtheria, and smallpox, it is probable that a certain local lack of vitality, or ulcerative tendency, co-operates with the pressure in producing the perforation. Every part of the drum-membrane is liable to become the site of such a spontaneously formed opening, but in a majority of instances the anterior inferior quadrant seems to be the favorite locality. As soon as a vent has been established, the pain usually begins to abate. The discharge continues for a variable length of time, generally from one to three weeks, and finally ceases. This occurrence usually takes place simultaneously with the healing of the perforation. The swelling and redness then disappear, and the hearing returns to its normal state.

While the simple course which I have just described, is that of the majority of cases of acute purulent inflammation of the middle ear, in not a few instances the disease runs a more complicated course, or even assumes a fatal form. The more important of these complications will be considered in the sections devoted to fractures of the temporal bone, chronic purulent inflammation of the middle ear, and diseases of the mastoid process. The participation of the cervical and post-auricular glands in the inflammatory process is a noticeable feature in quite a large proportion of cases of acute purulent inflammation of the middle ear. This sympathetic inflammation of the glands rarely calls for special attention.

In the simpler forms of acute purulent inflammation of the middle ear—and they constitute the great majority of cases—the prognosis is favorable, both as regards recovery of the sense of hearing, and as regards the effects of the disease upon the general health. There is a widespread belief among non-professional persons, that a perforation in the drum-membrane, no matter how established, means the destruction of the power of hearing. This is, happily, an error, and we may assure our patients with the greatest confidence that the mere establishment of a perforation in the membrana tympani, whether produced directly by disease or by the cutting edge of the knife, exerts little or no influence prejudicial to the hearing. In the vast majority of instances the perforation heals as soon as the discharge from the middle ear ceases. In fact, it often heals too soon, that is, before the swollen condi-

tion of the walls of the Eustachian tube has sufficiently subsided to permit the fluid secretions of the middle ear to find an outlet by this channel; and under these circumstances the membrana tympani is very likely to be subjected to considerable tension, from the pressure of these accumulating secretions.

The duration of a visible discharge from the ear is very variable. It often lasts only a few days, and then again it may continue for a period of several weeks. If the case pass into a chronic condition, the discharge may continue for years.

Inasmuch as the membrana tympani forms, anatomically, a part of the external auditory canal as well as of the middle ear, it may participate in the inflammation of either of these regions. Under certain circumstances, therefore, it may be difficult or even impossible to determine, by mere inspection, whether the appearances presented by the membrana tympani indicate a primary inflammation of the middle ear, or merely an extension of one that developed originally in the external meatus, and spread thence not only to the membrana tympani but also to the cutaneous wall of the osseous portion of the meatus. In the great majority of instances in which the true significance of this combined myringitis and otitis externa diffusa cannot be learned by mere inspection of the parts, we may easily arrive at a correct conclusion by testing the hearing of the affected ear, and by ascertaining how much pain the patient has experienced. If he can hear the ticking of a watch at a distance of several inches from the affected ear, and if he has had very little pain—possibly none at all—we may be confident that we are dealing with a case of primary inflammation of the external auditory canal, involving the dermoid portion of the drum-membrane. On the other hand, a primary inflammation of the middle ear, of sufficient severity to involve the coverings of the osseous position of the external auditory canal, could scarcely run its course so far without producing severe pain.

Treatment.—The most urgent indication, in the treatment of an acute inflammation of the middle ear, is to afford relief from the pain, which is sometimes severe. In young children, it is often an easy matter to accomplish this by simply applying heat and moisture in close proximity to the inflamed parts. In carrying out this procedure, however, it is important to pay considerable attention to details. The child should lie upon the side corresponding to the well ear, and water at a temperature of about 100° F. should be poured into the outer canal of the inflamed ear until it seems to be full. Then a hot, flaxseed-meal poultice, or a pad composed of several thicknesses of flannel wrung out of hot water, should immediately be placed over the ear and surrounding region. As an outside covering, and also as a means of holding the poultice properly in its place, a flannel cap with strings that can be tied under the chin, may be adjusted. As soon as the poultice or the hot cloths seem to have lost their heat, fresh ones should be ready at hand to supply their places. By this procedure, which brings the heat and moisture in close proximity to the inflamed parts, we shall rarely fail in children to arrest an acute inflammation of the middle ear, provided that it be not due to some specific poison like that of scarlet fever or diphtheria, and provided that the disease be not of too long standing. In adults, also, this plan of treatment is sometimes successful, but it is rare that a full-grown person will consent to submit to treatment of any kind, until the time has gone by when such simple, home-made measures are competent to arrest the progress of the inflammation. Still it is often possible, even at this late stage, to quiet the pain and arrest the further progress of the inflammation by the measures which I have described, and it is therefore well to give them a trial. Now and then we shall encounter a patient to whom some form of dry heat affords

greater relief than does the poultice or the hot douche. A soft, flannel bag filled with dried hops, and heated thoroughly before an open fire or in the oven, will be found to serve an excellent purpose in such cases. Bran, oatmeal, or coarse salt may be used in the place of the hops. A rubber-bag filled with hot water, and covered with flannel, is also a good substitute for the hop pillow. A still more perfect method of applying heat and moisture to the inflamed drum-membrane, is by means of a gravity douche, provided with a pronged, hard-rubber nozzle, such as will be described hereafter. By refilling the tin reservoir ("Clark's douche") or the rubber bag as often as may be required, a stream of warm water may be kept playing upon the inflamed parts as long a time as may be wished.

If these simpler measures fail, we may, according to the age, sex, and strength of the patient, apply from one to four leeches either immediately behind, or immediately in front of, the auricle, as close as possible to the tragus. As a rule, however, it will be found that the cases in which warm applications and rest in bed fail to alleviate the pain, are characterized either by a bulging condition of the posterior half of the drum-membrane, or by an intense inflammation of all the soft parts bordering upon the upper part of the membrane, without any recognizable bulging. The pain is due to the pressure of accumulated secretions upon an inflamed, and therefore highly sensitive, mucous membrane, and the most rational and conservative procedure is to remove the pressure by establishing an artificial opening in the *membrana tympani*, through which the secretions may find an easy escape. I will quote here briefly from my work on ear diseases, already referred to, all that I think it necessary to say with regard to this operation: If performed with a reasonable degree of care by a physician who knows something about the anatomy of the middle ear, it may be considered as a perfectly safe operation. There is but one real danger, and that is this: the operator may, with the point of his knife, injure the delicate attachments of the anvil, or drive the stirrup into the vestibule with such force as to rupture the annular ligament, or injure some of the delicate labyrinthine structures. However, the attachments of the stirrup to the oval window are quite strong, and this ossicle can unquestionably be handled rather roughly without serious injury being caused to the organ of hearing. The attachments of the hammer are also very powerful. On the other hand, those of the anvil are very feeble. This ossicle is, as it were, suspended between the hammer and the posterior wall of the tympanum. The bands which attach it to the hammer are extremely delicate. From these the anvil derives little or no stability; but from the peculiar interlocking of the articular surfaces it derives probably its chief strength. At best, however, this ossicle possesses very feeble supports, and may easily be disconnected from the hammer by the manipulations of an ignorant or careless operator. In incising the *membrana tympani*, therefore, we should so guide the end of the slender, spear-pointed knife that it shall not strike the end of the long process of the anvil, or the attached head of the stirrup. All these parts which are to be avoided, occupy, fortunately, a comparatively small portion of the area within which the knife can be used. This dangerous region occupies about half (the upper half) of the posterior superior quadrant. Hence we may, without the slightest fear of injuring the ossicles, begin our incision a little above the dividing-line, between the upper and lower posterior quadrants, and midway between the handle of the hammer and the periphery of the membrane, and carry it down nearly to the lower limit of the latter. The *membrana tympani secundaria* need give no anxiety, as it lies safely concealed in its niche of bone, quite out of reach of any straight instrument that may be introduced through the outer meatus. Furthermore, if the point of the blade be carried too far inward, the only result will be an incised

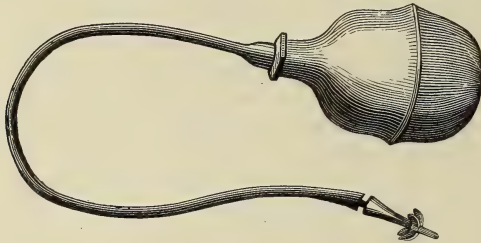
or punctured wound of the mucous membrane covering the inner bony wall of the tympanum, a result that has no significance in the pathological conditions now under consideration.

It is by no means an indifferent matter what sort of a cutting instrument is used in making an opening in the membrana tympani. In a general way, it may be said that a spear-pointed, two-edged blade is the best adapted to this purpose. In the construction of such a knife—or *myringotome*, as it is often called—regard must be had to the relations of the drum-membrane to the inner wall of the tympanum. Thus, for example, it is safe to assume that we shall never be called upon to incise a membrane whose posterior half occupies a position less than two millimetres distant from the inner wall of the tympanum. We may also take it for granted that we shall never find it necessary to incise a membrane so distended that it occupies a position more than five millimetres distant from the inner wall of the tympanum. It is therefore unnecessary to have the cutting edges of the spear-pointed knife of greater length than five millimetres. The myringotomes which I use have cutting edges only three and a half millimetres in length, and I find them amply long. In the next place, it is desirable that the spear-headed blade should be quite broad at its base; the breadth in this case being measured from cutting edge to cutting edge. In children and sensitive people, a single stab is often all that we can obtain, unless we resort to the use of an anæsthetic. Under such circumstances the broader the blade of our knife, the greater will be the length of our incision in the drum-membrane. In my instruments the greatest breadth is barely three millimetres. Possibly a breadth of three and a half millimetres would be found better adapted to all the purposes for which a myringotome is used; but we must not forget that we are often called upon to operate in a canal of very small calibre, and that even a slight increase in the size of the knife may be sufficient to greatly increase the difficulty of the task of operating successfully. It is largely a matter of individual preference whether a straight or a slightly bent myringotome shall be employed. After using both kinds, I have gradually fallen into the habit of using only the straight instrument. It seems to me that I can control such a straight myringotome more perfectly than I can a bent one. Those which I use are made from a single piece of steel, sixteen centimetres long; the slender shank, together with the blade, measures seven centimetres, while the eight-sided, roughened handle measures nine centimetres.

After an opening has been made in the drum-membrane, the hot applications described above should be continued until the pain has been relieved and until a free discharge has been established. Then heat is no longer required. The chief care from this time forward must be to secure the most perfect cleansing possible of the external auditory canal and outer surface of the drum-membrane, as long, at least, as the discharge continues. At first thought, one would be disposed to consider this part of his therapeutic task as very easy to accomplish. The fact is, this most important part of the treatment of purulent affections of the middle ear is rarely carried out properly. Two or three serious difficulties usually stand in the way. Of the numerous ear-syringes sold in the shops, both here and abroad, many are utterly worthless for the purpose; and of the remainder, scarcely one is fit for anybody but an expert to use. The syringing of the ear, however, must as a rule be carried out by a nurse or by some member of the family, or possibly even by the patient. The fear of injuring the ear by introducing the nozzle of the syringe too far into the auditory canal, is almost universal, and as a result the pus and masses of cast-off epidermis lying next to the membrana tympani remain undisturbed by the current of water ejected from the

syringe. They soon become putrid, and so increase the existing inflammation. If instructions are given to pull the auricle upward and backward during the operation of syringing, a more perfect cleansing of the parts is often obtained. But if the canal is swollen and tender, as is very apt to be the case, even this procedure will aid very little in rendering the syringing successful in its results. Several years ago I devised an instrument which has been sold under the name of "Reynders's douche," and which has been tried now for so long a time and so extensively that I feel no hesitation in recommending it as a very useful ear-syringe or douche. It consists of a soft-rubber bulb or reservoir, from one pole of which a short, flexible, rubber tube, eight or ten inches in length, leads to a hard-rubber tip or nozzle,

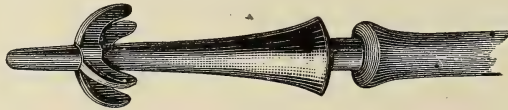
Fig. 954.



Ear-douche.

armed with lateral prongs that prevent the instrument from being pushed too far into the auditory canal.¹ This pronged nozzle, which constitutes the important part of the apparatus, is represented correctly in the accompanying illustration (Fig. 955). Instead of simple water I am in the habit of

Fig. 955.



Hard-rubber, pronged ear-nozzle; full size.

using, by preference, a saturated solution of boracic acid—two teaspoonfuls of the coarse crystals, or of the powdered acid, to the pint, or one tablespoonful to a litre of water. As boracic acid does not dissolve readily in tepid water, it is better to employ water that is decidedly hot, and then allow it to cool down to the proper temperature (about 100°–105° Fahr.) before it is injected into the ear. For cleansing purposes, it will be sufficient to douche the ear three or four times a day at first, and then, as the discharge becomes less active, we may resort to this procedure less and less frequently. When the discharge has apparently ceased, and when the water that escapes from the ear during the douching procedure seems to be quite clear, we may venture to dispense with the instrument altogether.

This is perhaps the proper place at which to call attention to a remedial

¹ At the present time, the best modification of this douche, for sale in New York, is that manufactured by T. Angelo, of Thirty-first Street and Fourth Avenue. The bulb contains a decidedly larger amount of water than did that first manufactured, and soft, black rubber is now used in place of the coarse, white variety, for the tube which connects the nozzle with the reservoir. These modifications have materially increased the efficacy of the instrument.

procedure which is very commonly employed, but which is, as I believe, objectionable. I refer to the instillation of warm laudanum and sweet oil into the external auditory canal, a remedy which is widely recommended by physicians in all cases of pain in the ear. This procedure does indeed, in some instances, diminish the pain, but it accomplishes this in an illegitimate manner, if I may so express myself. It deadens the nervous sensibility of the inflamed parts, but it does not arrest or diminish the inflammation. On the contrary, both the oil and the alcohol in the laudanum tend rather to increase the inflammation: the former, by reason of the numerous germs of vegetable mould which it contains, and which may quickly take root in the inflamed tissues; the latter, by reason of its well-known irritating properties.

In the majority of cases of acute inflammation of the middle ear, no other measures beside those which I have described will be found necessary for the restoration of the affected region to a condition of health. In a few cases, however, we find it desirable to resort to other expedients and remedies. Thus, for example, the discharge may show little or no tendency to diminish, although a period of two or three weeks may have elapsed since it first made its appearance, and although the most careful douching may have been practised. Perhaps the most common cause of this persistent discharge is what I might term a relaxed condition of the mucous membrane of the middle ear; its bloodvessels being dilated and paralyzed, and the surrounding tissues being infiltrated with serum and lymphoid cells. Such a mucous membrane needs the stimulating effects of nitrate of silver, and the problem which we have to solve is, how to bring it in contact with the diseased parts effectively and safely. If there is a large opening in the drum-membrane, the task is a very easy one. By aid of the douche and of inflations with a Politzer bag, we can usually remove the greater part of the secretions accumulated in the drum-cavity. A few drops of the solution are next to be instilled into the auditory canal, the head of the patient being turned to one side in such a manner as to favor the descent of the fluid to the inner end of the meatus; and then, after the solution has become warmed by the heat of the surrounding parts—that is, after the lapse of two or three minutes—sufficient pressure should be made upon the orifice of the canal to force the fluid contained in it to find its way into the affected drum-cavity, and perhaps also into the Eustachian tube and other outlying parts. While the pressure is being applied, the patient should be requested to perform the act of swallowing three or four times in succession, as the entrance of the remedial solution into the middle ear will thereby be materially facilitated. In cases of comparatively recent origin, weak solutions of nitrate of silver will usually be found sufficiently effective. If the perforation is as large as one-half of a millimetre in diameter, we may use, with perfect safety, solutions of from five to thirty grains to the ounce of water. I have rarely found it desirable to use a stronger solution than one containing five grains to the ounce. If the perforation is quite small, perhaps no larger than a small pin-hole, it is better to use a still weaker solution—one, for instance, that contains only two or three grains to the ounce. On the other hand, in cases in which the perforation measures as much as three millimetres in diameter, and the mucous membrane of the inner wall of the tympanum appears to be much swollen and congested, I frequently introduce a slender probe, upon whose knobbed end a bead of pure nitrate of silver has been fused, and pass it lightly over all the mucous membrane that is within reach. A single such application will sometimes arrest the discharge as if by magic, and the swelling and congestion then disappear gradually without any further therapeutic interference. If the perforation is very small, it is not an easy matter to bring our reme-

dies in contact with the tympanic mucous membrane, at least by any of the methods which I have thus far described.

Injections by means of the Eustachian catheter, are, under these circumstances, preferred by many authorities. This plan of treatment, however, is open to the objection that it gives the patient unnecessary discomfort, and often fails to introduce the remedial solution into the middle ear. A far more direct and perfect method is by means of slender glass or metal tubes, which can easily be passed through the smallest perforation. As it is necessary to introduce only a few drops of the remedial solution, it will be found convenient to attach to the tube an elastic cap, by means of which we may both draw up into it the remedy, and at the proper moment discharge it through the perforation into the drum-cavity. The accompanying cut is a faithful representation of such a glass tube with its elastic rubber attachment. Such a "middle-ear pipette" is very likely to inject only air into the middle ear unless we take care to elevate the reservoir end a little above the level of the

Fig. 956.



Middle-ear pipette; full size.

perforation. I need scarcely remind the reader that this apparently simple operation is not to be undertaken by everybody. Like very nearly all the manipulations necessary in either the examination or the treatment of the ear, this procedure requires skill in keeping the drum-membrane steadily illuminated, delicacy in the manipulation of the instrument, and a perfect knowledge of the whereabouts of the tip of the pipette in the middle ear.

Two or three questions still remain to be answered. In the first place, we must consider how frequently these remedial applications to the mucous membrane of the middle ear should be made. It is possible that the patient will make more rapid progress toward recovery if we apply our remedies to the affected part every day, than if we make the applications only three times a week. I have not tested this point thoroughly, and cannot therefore answer the question in a positive manner. I get excellent results from applications made only on alternate days, and I have sometimes found that I could, with apparent advantage, make the intervals even longer. I have therefore adopted the rule not to see patients who are affected with a purulent inflammation of the middle ear, oftener than three times a week. As a matter of course, we must see them oftener during the acute stage of the attack; but the rule which I have given applies only to the later stages. If the weaker solutions do not seem to diminish the discharge, I employ the stronger ones, and when these seem to increase the inflammation and the amount of the discharge, I return to the weaker solutions, or I abstain from all active interference for a few days, or I employ some other remedy. In this disease, however, I rarely find it necessary to resort to any other remedy, and the only articles that I use under such circumstances, are finely powdered iodoform, burnt alum, and boracic acid. As the condition of the ear improves under the use of nitrate of silver, there comes a time when nothing remains but a thin, scanty discharge, and there is no longer any visible evidence of active

inflammation. This is the time when a minute quantity of finely pulverized burnt alum, or of alum and iodoform mixed in equal parts, or of iodoform alone, if judiciously pushed through the perforation into the tympanum, will tighten up the relaxed tissues, and virtually put an end to the disease. As far as my experience goes, boracic acid is far inferior to iodoform in its curative powers, and furthermore it occasionally seems to act as an irritant. Burnt alum is an exceedingly valuable remedy, but it is only after long experience that one can use it satisfactorily. It sometimes sets up a pathological disturbance which it is hard to control. While I should probably fail if I were to attempt to lay down any accurate indication for its employment, I may say, in a general way, that it should always be introduced in very small quantities, and never when any trace remains of active inflammation. In particularly stubborn cases, we may find it necessary to administer cod-liver oil internally, or to send the patient away from home for a period of two or three weeks. Such a change of air and scene will often effect what the most painstaking and skilful treatment has failed to accomplish.

CHRONIC PURULENT INFLAMMATION OF THE MIDDLE EAR.—A chronic purulent inflammation of the middle ear may almost invariably be traced back to an acute attack that had its origin in a "cold," or in scarlet fever, measles, or some other infective disease. In a few cases the affection begins in an insidious manner, without pain, and apparently without any exciting cause. These comparatively rare instances are observed in scrofulous or consumptive individuals, and the middle-ear disease may then be set down as being of a distinctively tubercular or scrofulous nature. The salient feature of all these cases of chronic purulent inflammation of the middle ear, is the constant or frequently recurring discharge of pus from the affected region. With regard to all the other symptoms—the degree of the diminution in the hearing power, the presence or absence of pain, tinnitus, etc., and the lesions observable by the aid of the speculum and reflected light—the cases differ to such an extent that a general description would fit only a comparatively small number. Furthermore, if we look at this question from a practical point of view, from the standpoint of one who desires to effect a cure, we shall appreciate the folly of attempting to draw anything like a general picture of the disease. Each case must be a study by itself, and when the student wishes to make a diagnosis, he must strive to render an account to himself of the changes that are going on in all the different parts of the ear. If he rests satisfied with the mere diagnosis of "chronic purulent inflammation of the middle ear," and then consults some text-book for the purpose of ascertaining what is the proper treatment for the disease which bears this name, he will often fail to arrest a discharge which might otherwise be easily checked.

As the space allotted to this article is limited, I will make no attempt to classify the different types of chronic purulent inflammation of the middle ear, but will simply describe the plan which I usually follow when I am called upon to ascertain the seat and the extent of the disease in a case of protracted discharge from this organ. Every observer has his own particular method of getting at the truth, and yet these different methods all lead to the same result. The one which I have adopted, is probably, in all material respects, the same as that employed by many other observers. It is, briefly stated, as follows: I obtain from the patient, or from the parents or guardians, as clear an account as possible of the origin and progress of the affection. It is important to learn the degree of activity of the discharge, whether constant or intermittent, whether fetid in character, and whether pale or tinged with blood. I ascertain also whether pain has been an accompaniment of the disease, and endeavor to find out the precise locality to which the pain

has been referred. The value of the previous history of the case will be appreciated when we come to weigh the significance of certain lesions that may be discovered in the course of an actual inspection of the parts. We must also not forget to test the hearing of the affected ear. Then, if the case under consideration be one of a somewhat acute nature, our next step should be to ascertain the body temperature. Otherwise, we may proceed at once to an examination of the ear and neighboring parts. Pressure should be made with the finger upon the soft parts immediately surrounding the ear, and particularly upon those covering the mastoid portion of the temporal bone. An unnatural redness of the skin in this region is a valuable indication, and its presence should be noted. With all these facts in our possession—the previous history, the degree of diminution in the hearing, the body-temperature, and the condition of the skin in the immediate neighborhood of the ear—we shall be able to interpret correctly the pathological changes which we may see in the deeper parts of the organ. If the meatus is filled with pus, we must take steps to remove it, not simply in a general way, but in the most thorough manner, so as to expose to view every nook and cranny.

The question of syringing presents itself at this point. Is it best to remove the pus and other *débris* by syringing, or not? The answer to this question may be either yes or no. I never use the syringe under these circumstances: I much prefer to soak up the pus little by little, with a mop of absorbent cotton wound around the end of a slender, malleable, steel cotton-holder, and, in performing this operation, I keep the canal well illuminated and watch each step as I carry my mop deeper and deeper into the canal. If I were to syringe the meatus, I should still be obliged, afterward, to resort to the use of the mop; for the water that clings to the deeper parts of the ear and to all the irregular places, will be found to mask the true condition of the parts almost as effectively as if pus and not water covered them. It is therefore easier and better to omit the syringing, and to trust entirely to the mop. On the other hand, an unskilled person will have to employ the syringe, and he will have to interpret, as best he may, the ill-defined picture which he finds spread out before him. As an imperfect or an erroneous diagnosis leads, in very many of these cases, to equally imperfect treatment, it will be seen that I have a right to warn the reader against trusting to such an imperfect procedure as that of cleansing the ear by means of a syringe. Oftentimes we shall find it also necessary to use the slender middle-ear probe, the curette, and the angular forceps, in our efforts to clear away the obstacles that obstruct the view. These usually consist of scab-like formations, conglomerations of cheesy pus, and masses of epithelium. The latter often cling quite firmly to the underlying inflamed tissues, and require to be dissected off by means of the curette. When the mass has been detached, we can readily extract it by means of the slender, angular forceps. Irregularities of the surface must be touched and handled, if I may use the expression, with the probe or curette. In this way we often discover ulcerated areas or spots of granulation-tissue, which, under simple inspection, had seemed to be simple unevennesses of the surface. Sometimes the orifice of a sinus gets filled with cheesy pus or epithelial *débris*, and then presents the appearance of a mere white spot. Careful pressure with the end of the probe will at once reveal to us the existence of such a sinus, and by further manipulations with the same instrument we may ascertain its depth, the direction which it takes, and the presence, at some point in its course, of an exposed, bony surface, or of a loose fragment of bone. If the sinus is of sufficient size, we may gain a more accurate knowledge of its relations to neighboring cavities by the employment of a slender canula, of either metal or glass, through which, by the aid of an attached soft-rubber bulb-syringe, we may inject a

stream of tepid water into the mouth of the sinus. Every mass of granulation-tissue that springs from any part of the external auditory canal should lead us to search, in the immediate vicinity, for the presence of a sinus or of a spot of carious bone. Sometimes the sinus begins at the very edge of such a granulation growth. Perhaps equally often the opening will be found in the very centre of the mass.

Our attention should next be directed to the drum-membrane. Every part of it should be laid bare, so that we may feel sure that we know, from actual inspection, what is its condition. A perforation is rarely lacking. If it be quite small, and especially if the membrana tympani at this point be decidedly thicker than normal, we may fail to discover the existence of the perforation by simple inspection. We must then take advantage of Valsalva's experiment, and watch the effects of it upon the membrana tympani. As the compressed air finds a way of escape through the perforation in the drum-membrane, it is very likely to force out into the meatus a certain amount of the fluid contents of the tympanum. The locality occupied by the perforation is thus quickly revealed. In cases of this kind, we can only infer what the condition of the middle ear is from the appearance of the neighboring parts, and from a consideration of the data previously obtained. In cases in which the perforation is larger, we may obtain a direct view of the deeper parts, and if the perforation is quite large, we may be able to form a fairly accurate judgment with regard to the condition of the middle ear. Direct inspection, however, must always be supplemented by exploration with the probe. In this way we can learn the thickness and consistency of the tympanic mucous membrane, and the presence or absence of masses of epithelium and cheesy pus (the so-called cholesteatomata), especially when they lie concealed from view in the upper and posterior portions of the drum-cavity or in the antrum. In this way, also, polypoid growths are discovered at points which, to the unaided eye, seem to be covered only with a smooth though perhaps swollen mucous membrane. Bone ulcers, which are by no means rare lesions in the middle ear, can only be discovered by means of the probe.

The examination is now complete. In the great majority of cases, we know exactly what is the condition of the external auditory canal and membrana tympani, and we possess sufficient additional data to enable us to form a fairly accurate opinion with regard to the condition of the middle ear. In a few cases, the auditory canal is found to be in such a swollen condition that we are unable to gain a view of either the drum-membrane or the inner half of the meatus. Under these circumstances, we must carefully weigh the other objective phenomena, and the degree of impairment of the hearing in connection with the history of the case. The beginner may find it a very difficult task to clear up the pathology of these apparently obscure cases, but to the expert it will be comparatively easy to arrive at the truth. In our first attempt, we are obliged to go patiently through the process of analyzing each symptom, or lesion, in its relations to the others and to the history of the case. With each new case, however, this analytical process of reasoning will be found to consume less and less time, until, finally, we cease to be conscious of any such complicated process of reasoning, and arrive, as it were intuitively, at a correct judgment with regard to the nature of the malady. As I cannot hope, in a short article such as this, to clear up all the difficulties that surround the task of making a correct diagnosis, I will take up, in turn, the more important symptoms and lesions, and will endeavor to show the significance of each.

When *pain* occurs in the course of a chronic discharge from the ear, we may look for its source in a variety of places. It may be due, for example, to the development of a furuncle in the walls of the external auditory canal.

An irritating discharge from the ear is very apt to induce furuncular inflammation. The condition may easily be recognized upon an examination with the speculum and reflected light. The escape of pus from the middle ear under pressure, such as exists when a small perforation in the membrana tympani becomes blocked in any way, is a very common source of pain. After we have once verified the existence of such an insufficient or obstructed outlet, we can, by the aid of other symptoms and lesions, measure the extent of the harm that is being caused by the obstruction. Finally, decided pain of an obstinate character may be a very prominent symptom in chronic purulent inflammation of the middle ear, without the slightest trace of a condition of obstruction, or of active inflammation, of the visible portions of the middle ear. The pain, under these circumstances, is probably due to a chronic hypertrophic osteitis of the mastoid process. Farther on, I shall consider both of these classes of cases more fully.

Tenderness on pressure may exist in the auditory canal, or at any point in the immediate vicinity of the ear. Tenderness in the meatus signifies either a localized, furuncular inflammation, or a diffuse periostitis of the canal. In the case of this latter condition, we must endeavor to distinguish between a mere superficial inflammation, due to the exposure of the parts to a constant flow over them of an irritating pus, and one that represents a direct extension of a more or less serious inflammation of the middle ear. Tenderness behind and above the ear, if developed in the course of a chronic purulent discharge from the meatus, always means one of two pathological processes: either an inflammation of the soft parts of the auditory canal has travelled outward along the canal to the parts behind and above the ear, or an inflammation involving the antrum and cellular structures of the mastoid process has spread along the mastoid emissary veins to the outer periosteum. A study of the condition of the auditory canal will usually enable us to determine correctly which of these two processes is the one at work in the case under consideration.

In a large proportion of cases of chronic discharge from the ear, we may safely take it for granted that the discharge is kept up by a limited patch of *bone-caries*, usually superficial in character, or by a mass or masses of *granulation-tissue*. The latter condition is by far the more common of the two, though the former is by no means rare. There is undoubtedly such a thing as a persistent and fairly active discharge without either of the above-named conditions, but I am convinced that such a state of things is comparatively uncommon. Hence the necessity, if we desire to arrest the discharge, of making a most thorough and minute search for some hidden granulation-growth. In more than one case of obstinate discharge I have tried in vain to effect a cure. The perforation in the membrana tympani being small (a millimetre or a millimetre and a half in diameter), I have not been able to learn much, from actual exploration, about the condition of the middle ear. In a few of these cases I have had the good fortune, after the lapse of weeks or months, to discover the existence of a small polypoid growth in the tympanic cavity. At first it was too small to come within my limited range of vision, but as the mass increased in size it finally encroached upon the small field bordered by the edges of the perforation. The case then became quite clear, and the removal of the growth with the wire snare promptly put an end to the discharge. In some cases I have succeeded, by aid of the slender middle-ear probe, bent at a right angle near the tip, in bringing into a view a small polypoid growth, which the moment before had been completely concealed from view. With regard to bone-caries, I have very little to say that will be of practical value. My impression is, that I have found these patches or areas of bone-caries more often at the posterior end of the tympanum, just at

the edge of the entrance to the antrum, than at any other part of that cavity. The floor of the tympanum, and the lower part of the inner wall, just above the floor, are also localities in which such an area of bone-caries is apt to be found. Fistulous tracks in the region immediately above the membrana tympani are not uncommon.

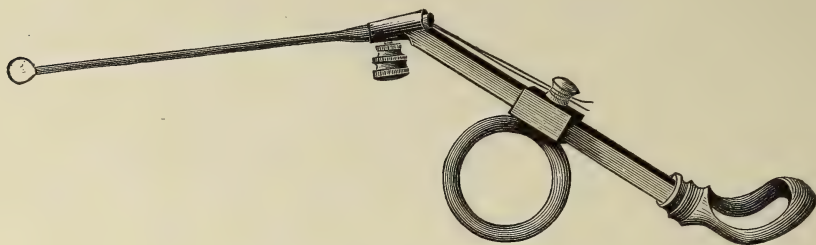
The *prognosis*, in all cases of chronic purulent inflammation of the middle ear, must be guarded. Our knowledge of the exact nature, location, and extent of the disease, is never sufficiently exact to justify us in giving a positively favorable prognosis. We are justified, however, in making the statement that judicious treatment succeeds, in the majority of cases, in either arresting the discharge entirely, or in rendering it so scanty that no outward evidence of its existence can be discovered by the ordinary observer. As far as danger to life is concerned, we may give a decidedly favorable prognosis in all cases in which the perforation in the membrana tympani is of good size, and the external auditory canal not materially narrowed by exostoses. The cases that are likely to assume a grave aspect, are those in which pus stagnates in the deeper recesses of the middle ear. In a few instances, the removal of mechanical obstacles (pus, masses of epidermis, granulation-growths, and undue swelling of the mucous membrane in the neighborhood of the labyrinthine windows and around the joints of the ossicula) decidedly improves the hearing, but in a large proportion of cases treatment fails to materially benefit the patient's condition in this respect. In fact, the hearing is sometimes rendered less acute; for, upon the arrest of the discharge, the chronically inflamed tissues become contracted, dry, and rigid, and the mobility of the ossicular apparatus is thereby impaired.

In principle, the *treatment* of these cases of chronic purulent inflammation of the middle ear is very simple. As stagnation and decomposition of the secretions are the chief source of all the inflammation, ulceration, and growth of granulation-tissue in the middle ear and external auditory canal, so our therapeutic efforts must be directed chiefly to the frequent and thorough removal of these secretions. In very many cases, this part of the treatment can be carried out perfectly well by the patient at home. According to the activity and the degree of foulness of the discharge, the ear should be douched or syringed from one to four or five times daily, either with simple, tepid water or, preferably, with a warm, saturated solution of boracic acid (about two drachms to the pint). If a sinus in the bone exists, or if there is a tendency to the accumulation of secretions in the mastoid antrum, or in the upper half of the tympanic cavity, the surgeon will have to wash out these regions, at least two or three times a week, by the aid of a suitable canula attached to a gravity-douche, or to a bulb-syringe. If the skin of the auditory canal, or the mucous membrane of the middle ear, be ulcerated, or in a granulating condition, at any point, we must apply pure nitrate of silver to the affected spot. A bead of the caustic can readily be fused upon the end of a probe or cotton-holder, and by means of such an instrument we may readily cauterize only the limited area that requires such treatment. A separate mass of granulation-tissue, no matter how small, can best be gotten rid of by means of a wire snare or loop, such as can be prepared in a few moments in the admirable instrument known as "Blake's snare." This instrument, which was first described as "Blake's modification of Wilde's snare," is so different from, and so decidedly superior to, the latter instrument, that I have no hesitation in speaking of it as simply Blake's snare. (Fig. 957.)

In the case of the smaller polypoid growths of granulation-tissue, the operation of passing the loop of wire over the growth is so comparatively simple that no particular description of it need be given. In the case of the larger growths, of which only the outer portion can be seen, there may be some

doubt as to what is the best course to pursue in removing them. If the polypus is so large as to fill the outer orifice, it may be removed by means of an ordinary dressing-forceps, or, better still, by means of a Hinton's polypus-forceps, provided that the growth be not of the firm, fibrous variety. The

Fig. 957.



Blake's snare; somewhat reduced in size.

mass should be firmly grasped between the blades of the instrument, and should then be separated from its deeper attachments by a combined rotary and pulling motion, or simply by direct traction. If the growth is situated more deeply in the canal, and reflected light is required to render the mass

Fig. 958.



Proper method of holding Blake's snare.

visible, such an instrument as Hinton's forceps will be found awkward to manage, and likely to produce pain. Blake's snare, armed with malleable steel wire (size No. 37), is the proper instrument to use under these circumstances. By aid of the slender, silver probe, the surgeon can ascertain whether the mass grows from the cutaneous walls of the canal, or from the middle ear or mastoid cells. Where the growth is of such size as to fill the canal, it is not necessary that he should satisfy himself of the exact situation of the base of the polypus before applying the loop of wire. It is sufficient for him to ascertain by actual probing that he can pass his snare over the mass to a given depth (distance from the orifice of the meatus) without encountering any obstacle. The loop is then pushed in over the mass to this depth, and tightened sufficiently to hold the polypus firmly in its grasp. If the growth be succulent and not very firm, and especially if it can easily be rotated about its long axis, steady traction should be made, in the hope of pulling out the polypus, peduncle and all. In not a few cases this object will be attained; but even if the effort fail to remove the entire growth, at least as much of the mass will be torn off as would have been if the wire had been made to cut through the polypus instead of simply grasping it firmly. If the growth is firm in texture, and not easily rotated, it is better to use the loop simply as a means of cutting off portions of the growth. Under these circumstances traction should not be employed. As soon as the bleeding has ceased, and the portion cut off by the wire loop has been removed with the bent forceps,

the remainder of the growth is to be treated in precisely the same way as the first portion. The wire loop is to be applied again and again until the base of the growth has been cut away to the level of the surrounding mucous membrane or skin. If the polypoid mass springs from some portion of the external auditory canal, it will be found as a rule decidedly firmer in texture and more sensitive than one of middle-ear origin. It will also not possess the same degree of mobility as the latter. The polypi of middle-ear origin, we shall find, spring more frequently from the upper and posterior portion of the tympanum (entrance to the antrum) than from any other locality.

It is a good rule in practice not to resort to the use of caustics until the base or peduncle of the polypus has been cut away with the snare to the level of the surrounding parts (skin or mucous membrane). Furthermore, in deciding whether the peduncle has been cut away to the proper level, we are not to trust to the sense of sight alone; the behavior of the peduncle, when circumscribed by the end of the probe, furnishes the only trustworthy guide to a knowledge of the exact relations which this peduncle bears to the surrounding parts. When the mass has been so far extirpated that we cannot encircle it with a wire, we may, with benefit to the patient, resort to the use of caustics and astringents.

In a few cases, after the removal of a polypoid growth from the ear, the hemorrhage from the divided vessels is quite active. This occurrence, however, need give us no anxiety, as the bleeding very rarely proves to be excessive. In placing the loop of wire over granulation-growths in the immediate neighborhood of the middle ear, great care must be taken not include one of the ossicles, especially the handle of the hammer, in the loop. After we have cut away as much of the growth as we can with the wire loop, if the remaining stump or base rise in the slightest degree above the surrounding level, we should apply caustic to the exposed raw surface. Care, however, must be taken not to cauterize the part too deeply. By some excellent authorities chromic acid is preferred to nitrate of silver as a caustic. While I feel more at home in the use of nitrate of silver, I am disposed to look upon chromic acid as a most useful caustic. The only objection that I can raise against it, is this: it must be applied to the affected part with decided caution, or its destructive action will extend to a greater depth than is desirable. The remedy should only be used in a fluid state (after deliquescence has taken place), as the old practice of depositing a minute crystal of the acid upon the part to be cauterized, often leads to the development of a severe and troublesome inflammation. Furthermore, it is a good plan not to make caustic applications oftener than on every other day. When we believe that we have accomplished all that is necessary in the matter of levelling the granulating area, we should abandon the caustic treatment, and apply powdered burnt alum to the affected spot. We should transport the alum, grain by grain, on the moistened end of a slender probe, until the part is well covered with the powder. The old plan of blowing the powder indiscriminately over all the deeper parts of the ear, is open to decided objections. Powdered iodoform, or boracic acid, may safely be blown, in a thin layer, over all these parts, but it is not good practice to use alum in this unrestricted manner, as it sometimes greatly aggravates the inflammation which we are striving so hard to control. When we find that the ulcerative process has involved the underlying bone, we must not be surprised if our therapeutic efforts prove only partially successful. Various plans of treatment have been tried for the cure of bone-caries in the outer or the middle ear, but I have not found any of them of special value. In cases of this nature, I carry out precisely the same plan of treatment as that which I have just described. As soon as I have succeeded in clearing the cavities of granulation-

growths, I dismiss the patient with careful instructions about cleansing the ear once or twice every day. Under this plan of systematic cleansing, the bone-disease is sometimes arrested, and the discharge ceases. Relapses, however, are common.

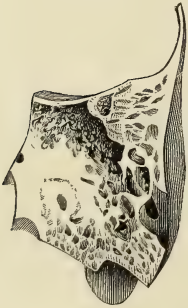
In a few cases, as I have already said, there is no discoverable disease of the bone, the external auditory canal appears to be sound, and nothing like granulation-tissue can be found in the middle ear. The promptly successful results of the treatment in these cases warrant the conclusion that the only pathological lesion upon which the discharge depends, must be a relaxed condition of the mucous membrane of the middle ear; a condition which, as I have already said, is probably characterized by paresis of the walls of the bloodvessels, and by the consequent infiltration of the mucous membrane with lymphoid cells and the watery elements of the blood. The application of a solution of nitrate of silver (from two to five grains to the ounce of water) to the entire lining membrane of the middle ear, either by means of the middle-ear pipette or in some coarser manner, usually brings the relaxed mucous membrane soon back to a quiet, non-secreting condition. In these cases, as a matter of course, the diagnosis can only be made after a cure has been effected.

With regard to the employment of more general measures in the treatment of chronic purulent inflammation of the middle ear, I must refer the reader to the remarks on acute purulent inflammation of this region.

DISEASES OF THE MASTOID PROCESS.

It has been the custom to speak of diseases of the mastoid process as if they were separate and distinct from the different types of inflammation of the middle ear. While, as a matter of fact, the two groups of diseases are inseparably connected, as a matter of expediency it is better that this custom of separating them should be maintained. The mastoid cells ordinarily participate in whatever inflammatory processes take place in the tympanic cavity, without manifesting any symptom that is likely to attract our attention to that quarter. In some cases, however, the symptoms pointing particularly to this region outweigh the others, and under such circumstances no hesitation need be felt in grouping these cases together under the title of diseases of the mastoid process. Before attempting to portray this class of cases, I will first describe briefly some of the more important anatomical features of the mastoid region, as it will be very difficult, without such knowledge, to understand the varying picture of mastoid disease.

Fig. 959.



Mastoid process of a child two or three years old. The darkly shaded region, above and toward the left, represents the antrum. A large pneumatic cell, whose thin outer wall of bone has been broken away, may be seen a little above the tip of the process.

At birth, the mastoid process consists of a small, flattened tuberosity, containing but one cell of material size—viz., the antrum. During the first year of infancy this cavity usually lies so near the outer surface of the process that only a thin wall of bone, perhaps only a millimetre in thickness, separates it from the external periosteum. Furthermore, this thin partition of bone is often perforated by quite a large opening, through which passes at least one of the mastoid emissary veins. It is important to remember these relations of the parts as they exist in

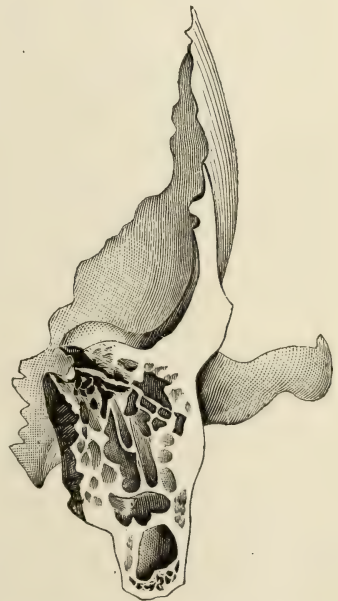
infancy; for without this knowledge we might experience great alarm over phenomena which, indeed, seem to point to serious disease, but which appear

comparatively harmless when interpreted in the light of the anatomical relations which I have just described. The phenomena to which I refer are these: A large swelling develops rather rapidly behind the ear of an infant, who has been fretful and feverish for a few days. There may or may not have been a slight discharge from the ear; but if there have been a discharge, it will have ceased before the swelling makes its appearance. From the fluctuation, which is readily discoverable, from the inflamed appearance of the neighboring skin, and from the elevation of the body-temperature, it becomes reasonably certain that the swelling represents an abscess. An incision is then made, and the correctness of the diagnosis is established; the recovery that follows is rapid and complete. I have had the opportunity of examining the ear in two or three such cases, and have satisfied myself that the pathology of these abscesses is simply this: The resistance offered to the pus accumulating in the cavities of the middle ear, happens to be less in the direction of the mastoid integuments than in that of the membrana tympani, and the pus accordingly forces a way for itself in this direction rather than through the tissues of the drum-membrane. The abscess is not, as in adult life, an indication of a severe and unchecked inflammation of the middle ear, but simply a revelation of the peculiarly free communication which happens to exist between the antrum and the outer surface of the mastoid bone. The absence of any marked swelling of the walls of the auditory canal shows clearly, in these cases, that the pus has not travelled outward—as we occasionally see it travel in older individuals—between the bone and the skin of the external meatus.

The anatomical relations of the antrum, in infantile life, have other important bearings of a practical nature. In the first place, the outer bony wall of this cavity is quite easily broken, at this period of life, by moderately firm pressure with some hard instrument. It is therefore easy to penetrate from without into the antrum, whenever the condition of the ear seems to call for such a procedure. In the next place, counter-irritation behind the ear, in quite young children, often produces promptly beneficial effects upon a sluggish inflammation of the middle ear. The explanation of this fact may be sought for in this peculiar nearness of the antrum to the skin covering the mastoid process, and in the intimate vascular and nervous relations that exist between the two regions.

The mastoid process of a child, four or five years of age, already presents all the essential features of that belonging to a full-grown adult. It is smaller, however, and the bone substance is still somewhat less dense and firm than it is in adult life. Even in its fully developed state, the mastoid bone will be found to vary greatly in size in different individuals. I can give no exact measurements, as the limits of the mastoid portion of the temporal bone are not sharply defined. I have a specimen, however, in which the distance between the upper and lower limits of the mastoid cells measures an inch and three quarters, while horizontally the extreme limits are an inch and a quarter apart. This speci-

Fig. 960.



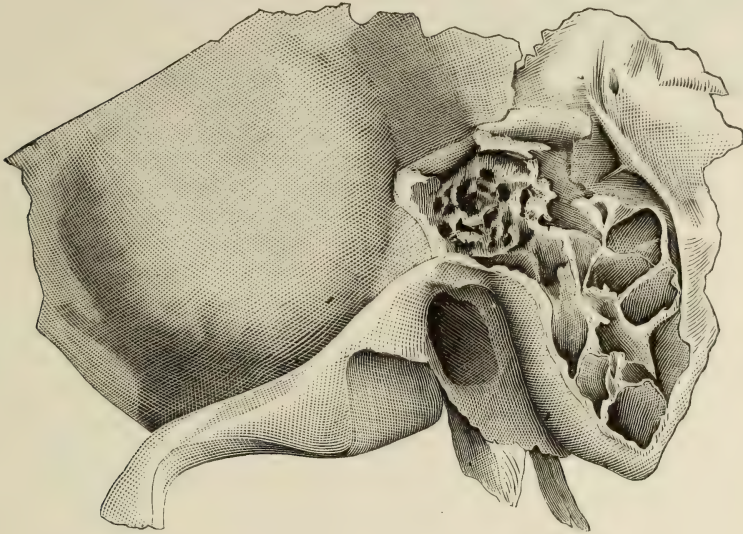
Mastoid process of adult. Transverse, vertical section.

men, I am satisfied, must be considered as an unusually large one, for among a number of temporal bones in my possession, I can find no other in which the mastoid cells are of equally great extent. Strictly speaking, the term mastoid process refers only to the lower, teat-like projection of the bone, but in this article, and in fact in medical parlance generally, the expression is intended to refer to all that portion of the temporal bone which contains the honeycombed structure usually found in the mastoid process. This peculiar structure consists of a number of small cavities or cells, which vary greatly in size and shape, not only in the same temporal bone, but also in those belonging to different individuals. Many of these cells, probably the great majority of them, are lined with an extension of the mucous membrane of the tympanum, and communicate one with another. Under normal conditions they contain air, and are therefore spoken of as the pneumatic cells. The remaining cavities are filled with a fatty tissue resembling that which is found in the diploë of fresh bones. Zuckerkandl, who examined one hundred mastoid processes in the fresh state, and one hundred and fifty macerated temporal bones, found that air-cavities were wholly lacking in twenty per cent. of the specimens, and that perfectly pneumatic mastoid processes, without any diploëtic spaces, represented only 38.6 per cent. of the entire number. Furthermore, he ascertained the fact that in some individuals only the lower half of the process was diploëtic, while the upper half was entirely pneumatic. These comparatively recent researches throw a great deal of light upon the pathology of acute and chronic purulent affections of the middle ear. They make it easy to comprehend how in one individual, whose mastoid cells are quite large and communicate freely one with another, an inflammation of the middle ear may, almost at the very onset of the attack, involve the mastoid region, while in another the same disease, in perhaps a far more severe form, will leave this region wholly unaffected. Unfortunately, Zuckerkandl's researches do not show whether we are permitted to consider the absence of pneumatic cells, in the specimens examined by him, as a perfectly natural peculiarity of construction, or whether these spaces may not have been obliterated by an unnatural hypertrophy of the bone, the result of disease.

We must next consider the mastoid cells in their relations to neighboring parts. Superiorly, they may extend as high as to within half an inch of the temporo-parietal suture. In this comparatively thin part of the temporal bone, they are separated on the outer side from the periosteum, and on the inner side from the dura mater, by a dense layer of bone, which varies from one to three millimetres in thickness. Anteriorly, the pneumatic cells extend forward over the external auditory canal. Posteriorly, they cease somewhat abruptly, that is, without any material diminution in size, in the immediate vicinity of the temporo-occipital suture. Hyrtl, according to the authority of Schwartz, found three skulls (among six hundred which he examined for this purpose) in which the pneumatic cells extended even into the occipital bone. I once, in trephining the skull, found pus between the outer and inner tables of the occipital bone, a short distance back of the temporo-occipital suture, and thought, at the time, that it had travelled along the diploëtic spaces from a large abscess which existed in the body of the mastoid process. In the light of Hyrtl's discovery, it now seems to me at least equally probable that the pus found at this remote spot was really lying in pneumatic spaces which stood in direct communication with those immediately surrounding the abscess. The lateral sinus occupies a groove in the bone in the immediate vicinity of the posterior limits of the mastoid cells. Not far from the centre of the irregularly shaped mass of mastoid cells, but much nearer to their inner than to their outer limit, lies a single cavity, known by the name of the "antrum," or "horizontal portion of the mastoid cells," as it is termed by

Toynbee. It opens anteriorly, by a comparatively large mouth, into the tympanum proper. Its floor usually lies at a higher level than that of the tympanum. Its walls present a honeycombed appearance, which is due to the presence of numerous openings leading into the surrounding pneumatic

Fig. 961.

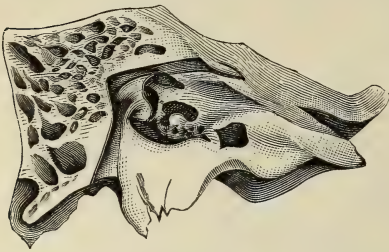


Extensive distribution of mastoid cells.

cells. A medium-sized pea would probably fill the antrum. Pneumatic cells are found on the inner and posterior sides of this cavity as well as on its outer side. They also extend to a considerable depth beneath its floor. In fact, they are absent only along the roof of the cavity. At this point a comparatively thin lamina of dense bone, often less than a millimetre in thickness, serves as a dividing partition between the dura mater above and the tympanic mucous membrane below. The distance from the posterior extremity of the antrum to the groove for the lateral sinus, varies from three to six millimetres (see Fig. 960); that from the outer wall of the cavity to the outer surface of the bone, varies from twelve to twenty millimetres (one-half to three-fourths of an inch). In cases of hyperostosis the antrum may be found to lie at even a greater distance from the outer surface of the bone. Finally, there are several points at which the bone surrounding the antrum is pierced by small channels which give passage to bloodvessels and lymphvessels, and their sheaths of connective tissue. The most important of these are: the petro-squamous fissure, which crosses the bony roof that is common to both cavities (the tympanum and the antrum); and the channels for the mastoid emissary veins, which traverse the bone from within outward. One of these canals commonly opens near the centre of the outer surface of the process, about on a level with the upper wall of the external auditory canal. Minute bloodvessels pass from the mucous membrane of the middle ear to the dura mater by way of the petro-squamous fissure, and by the same route an inflammation may spread from the ear to the brain. The redness, tenderness, and swelling of the mastoid integuments, in cases of inflammation of the

middle ear, may be explained by the assumption that the inflammation has followed the course of the mastoid emissary veins. Finally, I have still

Fig. 962.



Relations of facial canal to middle ear proper and mastoid cells; oblique, vertical section of temporal bone.

to mention the close proximity of the facial canal to the mastoid cells. In the immediate neighborhood of the mouth of the antrum, this canal turns sharply from its previous horizontal course, and passes directly downward through the pneumatic and diploëtic cells of the mastoid bone. It is therefore easy to understand why the facial nerve should be particularly liable to participate in any pathological changes that may take place in the mastoid cells.

Although the antrum and the tympanic cavity proper are, to all intents and purposes, one and the same region, and

although we have no just grounds for believing that, in an acute inflammation of the middle ear, the larger cavity of the tympanum is much more actively involved in the disease than the smaller cavity of the antrum, we are apt, it appears to me, to entertain this very belief. Our patients would fare better, I am confident, if we adopted the more rational view, and utilized the degree of inflammation presented by the drum-membrane and visible, adjacent parts, as a fairly true measure of that which must at the same time be going on in the antrum. In this connection, however, we must remember that in a few exceptional cases the membrana tympani may show comparatively insignificant evidences of inflammation, and yet an abscess may be present in the adjacent mastoid process. The mechanical relations of the tympanum proper, the antrum, and the pneumatic cells of the mastoid process, exert a determining influence upon the course of the inflammation that may from any cause be excited in them. At almost the very outset of such an inflammation, the only natural outlet which these cavities possess, viz., the Eustachian tube, becomes closed by the swelling of its walls. The conditions then are those of an inflammation taking place in a cavity whose walls, at every point but one, consist of unyielding bone. The membrana tympani represents the only point at which the accumulating products of the inflammation can force a way of escape for themselves. In a few instances the case may be in even a worse plight than that which I have just described. For example, the mouth of the antrum, or the mouths of the numerous pneumatic cavities which open directly into the antrum, may become closed; in which event the establishment of even a very free opening in the membrana tympani would fail to afford an exit for the secretions confined in those more remotely situated cavities. This occurrence is, I believe, not uncommon. The question then presents itself, what is likely to be the succession of pathological events if the products of inflammation are allowed to remain pent up in these cavities? If we possess some knowledge with regard to the individual's previous aural history, we may form a tolerably correct notion of what is likely to take place in these inflamed parts. In an individual who has not been subject to frequent or prolonged attacks of discharge from the ear, we may assume that the pneumatic cells still contained air at the time of the attack. In that case, the inflammatory exudation in the cells will soon change from a mere bloody serum to a thick pus, and, as the pressure increases, the lining mucous membrane of many of the cells will die and break down into purulent detritus. Even the thin bony partitions may soften and become detached. At all events, loose fragments of the

bony septa are sometimes found in recent abscesses of the mastoid process. In favorable cases, the pus may burrow a way for itself along one of the emissary canals, and pour its contents into the space between the outer surface of the bone and the periosteum, and through the latter into the cellular tissues behind the ear; or it may travel downward and develop an abscess in the soft parts below the mastoid process, between the skin and the muscles of the neck. In a third series of cases, the pus may work for itself a channel through the mass of bone which separates the floor and anterior part of the antrum from the upper and posterior wall of the auditory canal. Finally, if the resistance in these directions be too great, or if the channels of communication between the antrum and the intra-cranial cavity be unusually free, pus will find its way to the latter region, and will induce either a diffuse meningitis or an abscess in the very substance of the brain. It is possible, also, that in recent cases a carious process may be set up in that part of the bone which lies next to the groove for the lateral sinus, and that ulceration of this vein, with accompanying phlebitis, pyæmia, etc., may result therefrom. This issue, however, is to be looked for rather in chronic cases, in which the main portion of the pneumatic cells has been obliterated by sclerosis.

If a severe inflammation of the middle ear goes on unchecked, in an individual whose previous aural history points to the frequent occurrence or prolonged continuance of a discharge from this region, we may assume, with considerable confidence, that the majority of the pneumatic cells have become obliterated through a process of sclerosis. It will be seen at once that in such an ear the chances of a spontaneous cure are seriously diminished. When the antrum, in such a case, takes on a more acute type of inflammation, and when at the same time its natural outlet becomes obstructed or closed, the confined pus can no longer burrow a way for itself outward through the thick mass of ivory-like bone. The bony roof of the antrum is then likely to become carious, and the pus finds an outlet in this dangerous direction. Or the mass of bone which separates the antrum from the lateral sinus, and which, I believe, is largely composed of diploëtic spaces, breaks down under the effects of caries, and then the fatal issue is not long delayed.

In addition to these destructive forms of inflammation of the mastoid process, there is one which partakes rather of the nature of hypernutrition of the bone. To this form, which leads to the condition known as *sclerosis of the mastoid cells*, we shall give the name of *condensing osteitis of the mastoid process*. This type of mastoid inflammation has now been accepted, thanks chiefly to the writings of Dr. J. Orne Green, of Boston, as a fairly distinct disease, characterized by certain well-marked symptoms, and requiring, for the relief of the most prominent of these, a particular therapeutic procedure. A chronic hyperæmia of the mucous membrane lining the pneumatic cells, and also of the vascular connective tissue that fills the diploëtic spaces, undoubtedly constitutes the essence of this osteitis. A chronic inflammation of the mucous membrane of the tympanum proper, and of the antrum, furnishes the provocation for this hyperæmia. Increase in the amount of bone follows this chronic hyperæmia, and in the course of time this increase may even go so far as to obliterate the pneumatic spaces entirely. The constantly increasing pressure exerted upon the mucous membrane lining these spaces, explains the severe pain experienced by patients who are affected with this disease.

A *periostitis* of the mastoid process is always, I believe, to be interpreted as the result of direct violence (a blow or a fall), or as an extension of an inflammation, located either in the external auditory canal or in the mastoid cells. I have never seen anything that I could consider as a primary, idio-

pathic, mastoid periostitis, although such a disease has been described by different writers on otology.

In actual practice we find that no two cases of mastoid disease are exactly alike. At the same time, it is not a difficult matter to distinguish among them a few groups, in each of which there are certain distinguishing features which belong to the members of the group in common. Formerly I made a subdivision of these cases into five groups, but I am satisfied now that it is a better plan not to recognize more than three types of mastoid disease. They are as follows: (1) Subacute, condensing, mastoid osteitis; (2) Acute, diffuse, mastoid osteitis; (3) Chronic ulcerative inflammation of the mastoid antrum. These three groups differ materially from the three classes into which I have divided mastoid affections in my work on ear diseases. It is my belief and hope that this new subdivision, which simplifies the subject considerably, will enable the practitioner to arrive more quickly and surely at a correct diagnosis.

SUBACUTE CONDENSING MASTOID OSTEITIS.—(*Sclerosis or Hyperostosis of the Mastoid Process.*)—It is only a short time since the independent nature of this affection has been made known to us. It owes its origin to a chronic purulent inflammation of the antrum and other parts of the middle ear, but it may continue as an active disease for some time after the exciting cause has been removed. In very many cases it probably runs its course without giving rise to any decided symptoms, but in other instances severe pain and outward evidences of mastoid periostitis accompany the disease and reveal its existence to us. The protracted, subacute inflammation of the mucous membrane which lines the pneumatic cells, and also probably of the connective tissue which fills the diploëtic spaces, leads to the gradual filling up of both these cavities with bone substance. This form of osteitis rarely comes before us as a disease requiring treatment. It usually assumes importance when we are called upon to investigate and treat the other varieties of mastoid disease. The question is then sure to present itself: What is the condition of the mastoid cells which lie between the antrum and the outer surface of the bone? The following rule may safely guide us under these circumstances: If the history of the case reveal the previous existence of chronic purulent inflammation of the middle ear, we may assume that the mastoid cells have been greatly reduced in size, if not obliterated, by earlier attacks of subacute osteitis. In the few cases of condensing osteitis which are likely to come under our observation because they require treatment for the disease itself, we may very readily be led into the error of supposing that we are dealing with a case in which the essential lesion is an acute, diffuse, mastoid osteitis of a serious nature. The pain is sometimes so severe that no other diagnosis seems possible. Under these circumstances, we may be guided by the following considerations: If the case be one of simple, condensing, mastoid osteitis, our attention cannot fail to be drawn to the persistence of decided pain in and around the mastoid region, despite the existence of an adequate outlet in the drum-membrane for the pus secreted in the middle ear, despite the absence of anything like an acute inflammation of the middle ear or external auditory canal, or, finally, despite the employment of such therapeutic measures as would be likely to allay any ordinary inflammation of the mastoid structures. Furthermore, if, in addition to the pain, there be redness, tenderness, and swelling of the mastoid integuments—in the supposed case which we are now considering—these manifestations must be interpreted as furnishing corroborative evidence of the existence of a persistent, subacute inflammation of the underlying bony structures. Actual enlargement of the bone itself may

be considered as furnishing almost positive proof that the mastoid cells have been obliterated, or are still being obliterated, by a process of hyperostosis.

As far as the affection itself is concerned, the *prognosis* is by no means bad. The obliteration of the mastoid cells by the conversion of all this part of the mastoid process into solid bone, is apt to do harm only in two ways: It shuts off the possibility of a spontaneous cure in the event of the development of serious inflammation in the antrum; and it is also apt to prevent the development of those outward evidences which afford so valuable a warning of the existence of deep-seated disease in this part.

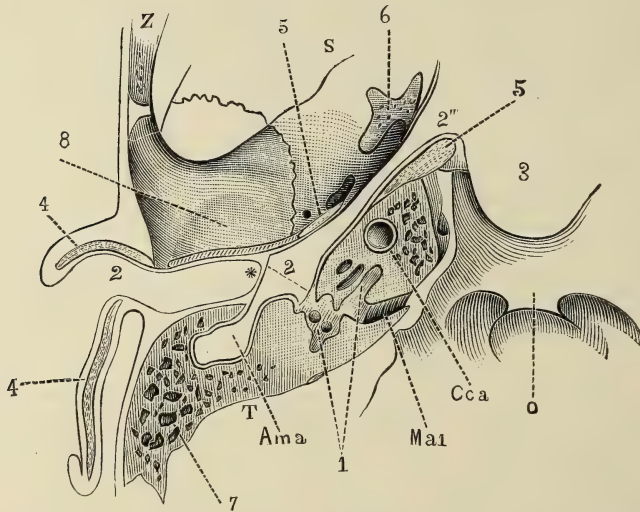
Treatment.—Hot poultices, leeches, and even Wilde's incision, will probably fail to give more than temporary relief. If such prove to be the case, and if the pain continue unabated, we should not hesitate to resort to perforation of the painful bone, with a drill or other suitable instrument. One opening will probably suffice, provided that it be carried to a depth of fully half an inch. As the beneficial effects of this operation, in a case of this nature, depend not upon the establishment of an outlet for pent-up products of inflammation, but rather upon the derivative effects exerted by such a wound in the bone, no effort need be made to reach the antrum. A straight, vertical incision may therefore be made through the mastoid integuments, and the point of the drill may be applied as far in front of this line, on a level with the upper wall of the meatus, as the stretching of the divided periosteum will permit. The healing of the wound may be delayed to advantage, by inserting into it a tent of sheet-lint, well anointed with carbolated vaseline. At the end of twenty-four, or at the most forty-eight hours, the tent should be removed. In addition to these measures, which are directed more particularly to the osteitis, we must not neglect to do whatever may be found necessary for the relief of the disease which involves the middle ear proper. The systematic cleansing of the antrum, by means of the douche, will often be found to serve an excellent purpose in these cases, though as a matter of course the local conditions may not always be such that we can resort to this procedure.

ACUTE DIFFUSE MASTOID OSTEITIS.—This variety of mastoid disease includes all the different degrees of inflammation which may develop in a previously healthy mastoid process. A widespread congestion of the antrum and pneumatic cells represents, therefore, the simplest type. The inflammation may cease spontaneously, or may be arrested by therapeutic interference, when it has reached this stage, and the parts may then gradually return to their normal condition. However, if the inflammation continue, both the antrum and the pneumatic cells will soon be filled with exudation, and whatever be the character of this exudation at first, it is sure before long to become distinctly purulent. I think it possible that, even after the disease has reached this advanced stage, a spontaneous recovery may still, under favorable circumstances, take place, without the formation of an abscess in the bone. I may mention, as one of these favorable circumstances, the sudden escape of part of the exudation, through one of the channels which naturally give passage to the mastoid emissary veins, into the soft parts on the side of the neck. It is more likely, however, that the disease, if left to itself, will pass from this second stage into a third, which is characterized by the death of some part or parts of the mastoid process. Pressure continued beyond a certain period is sure to result in the death of the mucous membrane pressed upon; and, in the case of the pneumatic cells, the mucous membrane is probably the only source of nourishment which very many of them possess. Hence the death of those bony septa which have been deprived of their periosteal coverings. Softening and disintegration of the bone follow next in order, and, if the pressure continue, we may expect the

area of dead bone to increase. In cases belonging to this second group of mastoid affections, this progressive death and ulceration of the bone are fortunately somewhat more likely to follow an outward course toward the skin than an upward direction toward the brain, or a backward one toward the lateral sinus. In this way a spontaneous cure has often taken place, the pus finding an outlet through a carious channel in the outer part of the mastoid bone. I have said that such a favorable issue is somewhat more likely to take place than the fatal one which is sure to follow ulceration either toward the lateral sinus or toward the brain, but I base my statement simply on an impression, and consequently I may easily be in error with regard to this point; and it is at least certain that the fatal cases belonging to this second group are numerous enough to warn us against trusting very much to the chances of spontaneous cure.

The *symptomatology* of this form of mastoid disease is at first precisely the same as that of an ordinary, acute, purulent inflammation of the middle ear. The pain, however, shows a marked tendency to persist, even when active measures are adopted for the purpose of alleviating it, and is apt gradually to involve the entire side of the head. Usually there is a moderate elevation of the body-temperature, though I have known even this symptom to be lacking. In a boy of eighteen, I once noted, just before establishing an artificial opening in the mastoid bone, a temperature of 105° Fahr. This is the highest temperature that I have ever observed in a case of acute inflammation of the ear. It fell to 99° F. soon after the operation. Redness, tenderness, and

Fig. 963.



Henle's diagram showing relations of all parts of the temporal bone to each other. 1, Various cavities constituting the labyrinth; 2, External auditory canal; 2', Tympanum; 2'', Pharyngeal mouth of the Eustachian tube. 3, Vault of pharynx. 4, Cartilaginous framework of auricle. 5, Inner cartilaginous lip of orifice of Eustachian tube; 5' Cartilaginous plate at tympanic orifice of Eustachian tube. 6, Pterygoid process of sphenoid bone. 7, Mastoid cells. 8, Glenoid fossa of temporal bone. * Membrana tympani. Ama, Mastoid antrum. Cca, Carotid canal. Mal, Meatus auditorius internus. O, Basilar process of occipital bone. S, Sphenoid bone. T, Temporal bone. Z, Zygoma.

swelling of the skin covering the mastoid process, indicate the existence of a mastoid periostitis; and the development of a mastoid periostitis, in the progress of an undoubted acute inflammation of the middle ear, admits of only one interpretation, viz., it indicates the existence of an inflammation of

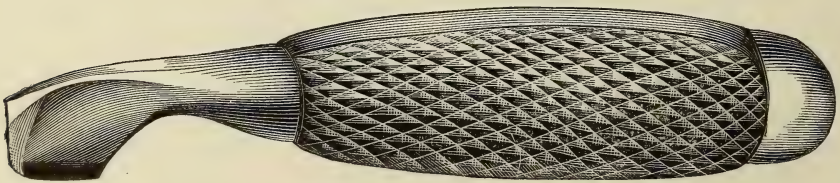
the mastoid cells. Unfortunately, it does not indicate how far the inflammation has progressed, but this important fact can be ascertained approximately in other ways. For example, the degree of redness and swelling of the upper and posterior cutaneous wall of the auditory canal, in the neighborhood of the membrana tympani, furnishes a safe criterion of the activity of the inflammation in the antrum. A glance at Fig. 963 will show how near the cavities are to each other at this point. The duration and severity of the pain, both in the mastoid region and throughout the entire side of the head, must also be remembered when we are endeavoring to decide in our minds what is the exact condition of the mastoid structures. In the presence, therefore, of well-marked mastoid periostitis, of decided redness and appreciable swelling of the skin along the posterior and upper wall of the meatus, close to the drum-membrane, and of a history of pain behind the ear and throughout the entire side of the head for a period of not less than one week, we may unhesitatingly assume that the inflammation of the antrum and pneumatic cells has reached a stage in which pus has certainly formed in the antrum, and probably in many of the pneumatic cells. If a prolapse of the posterior and upper cutaneous wall of the meatus has already taken place, we can feel confident that the disease has gone even farther, and that caries is liable to ensue at any time if it have not already occurred. This drooping or separation of the skin from that portion of the bony wall which serves at the same time as the floor or anterior wall of the antrum, indicates a high degree of inflammation in this particular region of bone; and if the adjacent body of the mastoid process is still pneumatic—and, in the class of cases which we are now considering, we have a right to assume that it is still in that condition—it is scarcely conceivable that it should not be participating, to a more or less marked degree, in the inflammation.

Treatment.—The moment we have gained a reasonably clear conception of what is the nature and extent of the disease which we are called upon to treat, the course which we ought to pursue lies clearly marked out before us. We should ask ourselves, first, this question: Is the outlet for the discharge, by way of the external auditory canal, as free as it can be made by any reasonable operative interference? If obstructions still remain—if granulation-growths or masses of epidermis and pus block the way, or if the opening in the membrana tympani be too small—these hindrances should be removed. Our next question should be: To what stage has the inflammation of the mastoid structures progressed? If we have reason to believe that the parts are simply congested, we may trust to the application of from two to five leeches, according to the age and strength of the patient, and afterward to a thoroughly carried out system of hot poulticing. The leeches may all be applied directly over the mastoid process, or some of them may be applied at that point and the others directly in front of the outer orifice, as close as possible to the tragus. Rest in bed is a far more important feature of the successful treatment of these acute affections of the ear than very many of us suppose. On the other hand, if our minds are somewhat in doubt about the wisdom of trusting to these simpler and less powerful measures, or if we have tried them and they have failed to relieve the pain, we should promptly resort to a "Wilde's incision." In this operation, the skin and subjacent tissues, including the periosteum, are divided by an incision extending from the base very nearly to the apex of the mastoid process, the external wound measuring from three-fourths of an inch to an inch in length. If the patient's head is in the erect position, the point of the knife should be introduced into the skin about on a level with the upper wall of the external orifice of the auditory canal. If we begin the incision higher up, we shall be apt to divide a branch of the posterior auricular artery, which usually

crosses the bone at about that level. On the other hand, if we make the incision a little too far forward, we may nick this artery or incise it longitudinally, and so prepare the way for the development of a false aneurism, as has already twice happened; once in my own practice and once in that of Dr. Charles J. Kipp, of Newark, N. J. After the bleeding from the wound has ceased—and, within reasonable limits, the more protracted and the more copious the bleeding, the better—I usually introduce a small tent well-smeared with vaseline, for the purpose of preventing the wound from healing by first intention. Hot flaxseed-meal poultices should then be applied to the mastoid region as often as may be found necessary to keep the parts warm and moist. As Sir William Wilde, of Dublin, Ireland, was the first to call attention to the decided, restraining influence which such deep incisions of the mastoid integuments exert upon an inflammation of the body of that bone, it is eminently proper that the name of “Wilde’s incision” should be retained for this most efficient therapeutic procedure.

Finally, in those cases in which the pain has persisted steadily for several days, and has perhaps resisted all the measures that may have been adopted for its relief—and in which all the local signs point quite clearly to a serious degree of inflammation in the body of the mastoid process—we should proceed without further delay to establish a broad opening in the outer part of this bony prominence. The steps of this operation, which ordinarily must be performed with the aid of an anæsthetic,¹ are as follows: First, the outer surface of the mastoid bone must be laid bare. Formerly I was in the habit of doing this by means of a longitudinal incision, which terminated below at the tip of the process. I found, however, that in pushing the periosteum forward, so as to lay bare the bone in the vicinity of the meatus, I encountered a troublesome degree of resistance on the part of this strong fibrous sheath. My present plan is to make an obtuse-angled or crescent-shaped incision, of which the upper end begins above the meatus, in the hairy scalp (which in this region must first be shaved), while the lower end reaches nearly to the tip of the process. If this sort of an incision be made, no difficulty will be experienced in pushing the periosteum forward, and in exposing the surface of the process fully to view. If the periosteum adheres firmly to the underlying bone, I find it desirable to employ a strong, dull-edged knife such as is represented in Fig. 964. If the bone be found softened

Fig. 964.



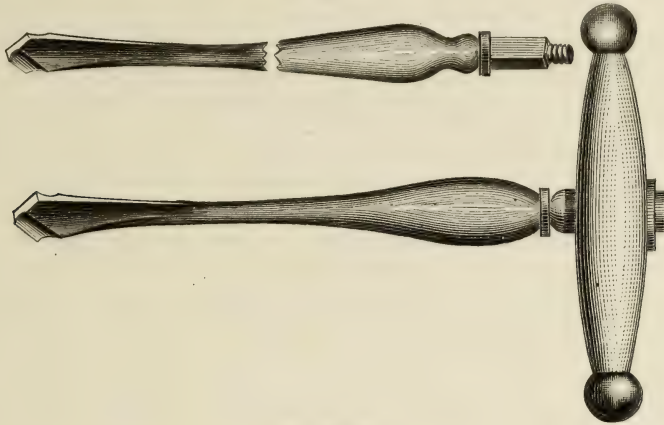
Strong periosteum knife.

at any point, the attempt should be made to break through it at this spot, and thus complete the work which nature has begun. The outer surface of the bone, however, is usually found to present a normal appearance. Under such circumstances, the drill should be applied to the bone at a point about a quarter of an inch distant from the orifice of the canal, and a little below the level of its upper wall. The instrument should then be rotated in a direction inward, a little forward, and a little upward, that is, in a direction nearly

¹ In three instances I have, at the patient's earnest request, performed the operation without the aid of an anæsthetic.

parallel with the auditory canal. The forefinger of the hand which guides the drill should rest firmly against the bone. If this precaution be taken, there will not be the slightest danger of our suddenly plunging the sharp point of the drill into parts which might thereby receive serious damage. The instrument should be constructed in such a manner that its cutting edges shall be turned in opposite directions. The accompanying figure shows this feature of the instrument very clearly. An operator whose fingers are unusually short, might perhaps find the drills a little too long; in which case he

Fig. 965.



Mastoid drills.

would find it necessary to have them shortened. When the drill has penetrated into the bone to an appreciable distance, it should be withdrawn, and the exact depth of the opening should be ascertained. After a few more turns of the instrument have been made, the depth should be measured a second time. The antrum should be reached at a depth not exceeding three-fifths of an inch. My rule is, never to force the instrument beyond a depth of twenty millimetres, or three-quarters of an inch. Schwartz, of Halle, in Germany, who has probably had more experience in this class of cases than any other surgeon living, places the extreme limit at twenty-five millimetres. When the end of the drill reaches the pneumatic cells, we must manipulate it more carefully, as our object is to establish a cylindrical outlet, and not to break down the cell walls throughout a large area. I always begin the operation with the larger drill, and then employ the smaller one, when I find that I am in danger of using too great leverage force. In this connection I should state that it has been ascertained by experience that, in very many cases, it is sufficient to carry the drill simply far enough inward to reach one or more of the pneumatic cells. I have repeatedly stopped short of the antrum, in operating upon the mastoid bone, and in all these cases I have obtained as perfect results as I have in those in which the opening was made to terminate directly in that cavity. Such a favorable issue is to be attributed, in some cases, to the fact that in establishing a communication between the outer air and some of the pneumatic cells, we have in reality established a communication—somewhat indirect, it is true—with the antrum itself. In other cases, the benefit derived from this incomplete operation can only be explained on the assumption that the establishment of a new centre of inflammation, in close proximity to that which has hitherto been the real centre of disease, produces a strongly derivative effect, and so checks the progress of the fundamental malady. Whether these speculations about the

mode of action of this operation be true or not, the fact is now well established, that through its instrumentality patients experience prompt relief from pain, and that the disease is rapidly brought under control, and in due time cured.

If a collection of pus is reached, in the course of the operation, we should search carefully for loose fragments of bone, and should remove them with the forceps, if any be found. Then, before dressing the outer wound, we should wash out the channel in the bone, or the antrum, as the case may be, with a five-per-cent. solution of carbolic acid. In carrying out this procedure, it is well to employ a nozzle or tube that is smaller than the artificial channel, so as to allow room for the return current to find a free outlet by the side of the instrument. At first no attempt should be made to approximate the widely separated edges of the wound. The more open the outer wound, the more easily shall we be able, at the daily dressing, to cleanse the deeper cavities. As an outside dressing we may apply, first, a suitable patch of lint well smeared with carbolated vaseline. Then outside of this, during the first twenty-four hours, flaxseed-meal poultices should be applied at short intervals of time. After the first day, the channel in the bone, or the antrum, as the case may be, should be thoroughly washed out once a day with either a warm, saturated solution of boracic acid, or a weak (two-per-cent.) solution of carbolic acid. When the outer wound so far heals up that the nozzle of the douche can no longer be introduced into the opening in the bone without causing the patient considerable pain, this part of the treatment may be omitted. I have known the outer wound to close permanently as early as on the tenth day after the operation. Then again, I have known it to remain unclosed for a period of several months.

CHRONIC ULCERATIVE INFLAMMATION OF THE MASTOID ANTRUM.—From this class of mastoid affections, come probably the greater number of fatal cases of ear disease. Through a period of months or, more commonly, of years, the patient is affected with a chronic discharge from the ear. The underlying disease begins as a simple purulent inflammation of the middle ear, and then, in the course of time, usually through the instrumentality of an obstructed outlet, the solid elements of the discharge—pus-cells, epithelium, detritus, cholestearin-crystals, etc.—begin to accumulate in the antrum. While these changes are taking place, the mastoid cells are being steadily reduced in size by a chronic osteitis, and, by the time that the accumulating solid matters have filled the antrum, the mastoid process will be found to have reached the condition of complete sclerosis. Ulceration of the walls of the antrum, in whatever direction the least resistance is met with, follows surely upon the formation of one of these foul-smelling masses of cheesy material in that cavity. The directions in which the resistance is least are, first, upward toward the brain, and next, backward toward the lateral sinus. In one or both of these directions, therefore, a destructive carious process may be expected to take place, if a vent be not established by artificial means sufficiently early to prevent such an issue.

In this variety of mastoid disease, pain, at times severe, is the most prominent symptom. While in the previously described variety external evidences of the underlying mastoid disease are rarely wanting, in this form of the disease they are rarely present, and then only when the disease is far advanced. On the other hand, one can usually find unmistakable evidence that the outlet through which the pus has been escaping from the middle ear into the auditory canal, is too narrow to permit the discharge to escape freely from the more deeply situated cavities. The persistence of pain, therefore, under such circumstances, becomes a very important indication—in fact, often the only

indication—of the severity of the deeper-lying ulcerative inflammation. If we wait for the development of additional manifestations of this treacherous disease of the antrum, before taking active steps to check it, we may rest assured that in many cases we shall let slip the golden opportunity of saving the patient's life.

Cases are now and then encountered in which, by skilful interference, we may succeed in clearing the antrum of its foul contents, and in re-establishing a free outlet for the secretions that constantly accumulate in it, without boring through the outer portion of the mastoid process. As a rule, however, this is not practicable, and in one case I am confident that my efforts to accomplish this difficult task only resulted in adding to the existing pain, and in hastening the fatal issue. In a general way, we may say that this form of mastoid disease admits of only one safe and effective plan of treatment, viz., that which consists in the establishment of a free channel of communication between the antrum and the outer air, through the mastoid process. The drill must be carried down actually to the antrum, and not merely to some still open pneumatic cell, if such should be found.

In the preceding description of mastoid diseases, I have been careful to portray only uncomplicated, well-defined types of these affections. I will now recapitulate very briefly the main, distinctive features of these diseases, in the hope of rendering this branch of the subject still clearer. The first variety of the mastoid disease—subacute, condensing, mastoid osteitis—is really nothing but an accompaniment of an ordinary, chronic, purulent inflammation of the middle ear. It does not immediately threaten either the life or the health of the patient. It may not even cause pain, and under such circumstances we are not likely even to have our attention drawn to the fact that the disease is present. In a few instances, the single symptom of pain becomes a prominent feature of the disease—so prominent, indeed, that we may be obliged to resort to the operation of boring into the mastoid bone in order to secure for the patient the desired relief. Here then we have a well-defined and very important type of mastoid disease. But its importance does not cease here. The chief result of this condensing osteitis is the obliteration of the pneumatic cells of the mastoid process. In ulcerative disease of the antrum, therefore, this condensing osteitis plays an important part. It commonly prevents the development of certain symptoms which are of great diagnostic value, and at the same time it interposes a solid wall of bone between the cavity of the antrum and the outer air, thereby greatly enhancing the serious character of an ulcerative inflammation of that cavity.

The second and third varieties differ in these respects: in the former, the pneumatic cells participate in the inflammation of the antrum, while in the latter they play no part as a separate system of cavities, but a very important one as a wall of bone impenetrable to ulcerative processes. In acute, diffuse, mastoid osteitis, we can generally limit our operative interference to the establishment of a free communication between some of the pneumatic cells and the outer air; while in chronic, ulcerative inflammation of the mastoid antrum, we must carry the artificial canal down to this cavity.

SIGNIFICANCE OF CERTAIN PHENOMENA OCCASIONALLY MET WITH IN DISEASES OF THE MASTOID PROCESS.—In addition to the symptoms described above, there are others which occur more or less frequently in affections of the mastoid process, and which should at least receive mention in these pages. Thus, for example, partial or complete paralysis of the facial nerve often develops during the progress of either the second or the third form of mastoid disease. It is probably brought about by the pressure of an effusion

that has been poured out into the bony canal through which the facial nerve passes. That such an effusion should take place, shows that the inflammation of the bone in the vicinity of the antrum has reached a serious degree of activity. The symptom is therefore of decided diagnostic value. In some cases permanent paralysis remains after the mastoid disease has entirely subsided, while in others every trace of the paralysis disappears in the course of a few weeks.

Sometimes the tissues on the side of the neck, a short distance below the tip of the mastoid process, become inflamed, and swell rather rapidly into a hard, flattened, and very sensitive tumor. The skin covering this matted cake of inflamed glands and other soft parts lying outside of the muscles of the neck, is red, œdematous, and firmly adherent to the underlying tumor. I have sometimes observed that the development of such a swelling takes place simultaneously with a decided subsidence of the pain in the mastoid region and side of the head, and for this reason I have been disposed to believe that some of the acrid secretion contained in the antrum or pneumatic cells, must have found a way of escape through one of the canals for the mastoid emissary veins, thus diminishing the degree of pressure within the mastoid process, and at the same exciting, by its acrid properties, a sharp inflammation of the tissues into which it first escaped. It is also possible, as suggested by Dr. J. Orne Green, of Boston, that a phlebitis of one of the mastoid emissary veins may be the cause of such a swelling of the soft parts below the mastoid process. By the frequent application of hot flaxseed-meal poultices, I have known such swellings to disperse without the development of an actual abscess. However, if pus forms, the knife must be used.

In several cases I have observed the development of an abscess, or at least of a circumscribed area of inflammation, in some part of the scalp of the corresponding side of the head. I believe that any part of the scalp may become the seat of such an abscess, or of such a localized inflammatory swelling, as I have encountered them in very different regions, viz., in the vicinity of the occiput, on the very top of the head, midway between the top of the head and the mastoid region, and in the temporal region. It seems to me reasonable to suppose that the lymphatics carry some of the acrid secretions from the mastoid cavities to these different localities, thus starting, by transportation, new centres of inflammation. In opening such abscesses I have sometimes been annoyed by the profuseness and obstinacy of the bleeding.

As a rule, the body-temperature may be taken as a measure of the activity of the disease in the mastoid process. This is particularly true of youthful subjects. In adults, however, we must not allow ourselves to be lulled into a sense of security by reason of the absence of noticeable fever. In one of my cases, which terminated fatally (probably from abscess of the brain), the temperature, during the last thirteen days, did not once rise above 100° F. Delirium does not necessarily indicate a fatal issue. Coma and strabismus, on the other hand, are more grave symptoms, for they point clearly to the development of intra-cranial processes which are quite likely to terminate in death.

FRACTURES OF THE TEMPORAL BONE.

As the subject of fractures of the temporal bone is considered in the article on Injuries of the Head, I shall confine myself in this place to a very brief presentation of those aspects of the subject to which the general surgeon as a rule pays very little attention. The so-called "fractures at the base of the skull" probably always involve the temporal bone. These cases do

not often come under the observation of the aural surgeon, and the medical man first called to see the case probably never thinks of making an examination (with the speculum and reflected light) of the external auditory canal and drum-membrane. Hence our supply of facts with regard to the lesions demonstrable during life in the temporal bone of a person who is believed to have a fracture at the base of the skull, is very scanty. It is sufficient, however, to justify the following deductions.

Fractures of the temporal bone may be subdivided into two classes:—

1. Fracture or diastasis of the tympanic or squamous portion, in the region of the middle ear, without implication of the pars petrosa.

2. Fracture of both the tympanic and the petrous portions.

Both of these kinds of fracture are produced, not by direct violence to the parts, but by *contrecoup*; that is, the patient, in falling, strikes upon the back or the top of his head, while the fracture occurs at the base of the skull. In the first variety, the line or lines of fracture correspond with the lines of union of the three bony portions which together form the temporal bone, and which in foetal life represent separate centres of growth, viz., the squamous portion (together with the zygoma), the tympanic portion (annulus tympanicus), and the petrous portion (together with the mastoid process). These fractures, therefore, partake somewhat of the nature of diastases. In the second variety, the fracture of the petrous portion of the temporal bone represents a genuine fracture. It takes place in the middle part of the bone, where it is greatly weakened by the presence of several large cavities (the meatus auditorius internus, the cochlea, the vestibule, and the semicircular canals), which are separated one from another by comparatively thin partitions of bone. While it is possible that a fracture may take place in the petrous portion of the temporal bone without a contemporaneous fracture or diastasis in the adjacent squamous or tympanic portion, we possess no facts as yet which will justify such a belief. In fact, the general surgeon is not in the habit of recognizing even two subdivisions, such as I have here made. Now I am satisfied that these subdivisions are by no means fanciful, but rather the reverse: they are eminently practical. Let me illustrate. A person falls or receives a blow upon the head. Bleeding from the ear follows, and may even be copious in amount. He is unable to hear the ticking of a watch in the affected ear, and, when the good ear is closed, he finds difficulty in distinguishing spoken words. The general surgeon, if he make the attempt to locate the fracture without resorting to an examination of the ear, will be very likely to make this diagnosis: fracture of the temporal bone through its petrous portion; a diagnosis which almost necessarily implies the permanent loss of the hearing of the corresponding ear. On the other hand, an examination of the ear with the speculum and reflected light might show a fracture running along the Glaserian fissure, and a tympanic cavity filled with blood. By aid of the tuning-fork, the fact might also be learned that the sonorous vibrations of this instrument were heard best in the affected ear. The diagnosis would then have to be made of a fracture involving the squamous and tympanic portions, and not the petrous; and the patient could properly be encouraged to hope for a partial, if not a complete, restoration of the hearing. Furthermore, the knowledge gained by such an examination of the ear would be likely to materially modify the treatment that would otherwise be adopted.

There are still other phenomena with regard to which the general surgeon is more than likely to form an erroneous opinion, if he do not take advantage of the light which an examination of the ear is competent to afford him. I refer particularly to two symptoms, viz., hemorrhage from the ear, and a watery discharge from the same region. In cases of fracture of the temporal

bone, a hemorrhage from the ear means, as a rule, a rupture of the bloodvessels in the vicinity of Shrapnell's membrane. Such a hemorrhage may be copious, and may continue for a comparatively long time; and the mere fact of its copiousness does not indicate that a communication has been opened between the cavity of the tympanum and any of the large vascular channels which surround the temporal bone. I am convinced, from actual observation in numerous cases, that the bloodvessels in the neighborhood of Shrapnell's membrane, are amply able, under favorable circumstances, to provide both a copious and a prolonged bleeding. I am also satisfied, from examinations which I have made in cases of injury to the head of recent occurrence, that fractures of the temporal bone often occur without the slightest bleeding from the external auditory canal. That these views, however, are at variance with those of the best surgical authorities, may be gathered from the following statement, which I have copied from Sir Prescott Hewett's remarks on Fractures of the Base of the Skull, in Holmes's System of Surgery:—

“Bleeding from the ears, in severe injuries of the head, has, for many years past, been held, and deservedly too, as one of the most valuable diagnostic signs of fractured base. But this bleeding, to be of any value as a means of diagnosis, must be of a serious nature, and, above all, it must continue for some time. With such a bleeding it may be safely diagnosed that there is a fracture of the base running through the petrous bone, and opening up a communication between the cavity of the tympanum and some of the numerous and large vascular channels which surround this bone, or with an extravasation of blood within the cranium itself.”

The other symptom, which is considered to be of so great diagnostic value in cases of suspected fracture of the temporal bone, is that of a watery discharge from the external auditory canal. While our direct knowledge with regard to this symptom is almost a blank, apparently no examinations having been made of the ear in suitable cases, a general knowledge of ear-diseases and of the anatomy of the temporal bone would prevent me from accepting in their entirety the views put forward by Sir Prescott Hewett in the following paragraphs, taken from the article quoted above:—

“There are, then, as far as is known at present, three classes of cases of this watery discharge. In the first class, where the fluid from the ear is plentiful and of a decidedly watery character immediately after the accident, there need be no doubt as to the nature of the injury—the watery discharge is due to the escape of the cerebro-spinal fluid; which, as already stated, can only take place through a fracture of the petrous bone implicating the internal auditory canal and its membranes.

“In the second class of cases, characterized by a copious and prolonged bleeding from the ear, followed by a watery discharge, a fracture of the petrous bone may also be safely diagnosed; but it cannot be said that the fracture follows any particular course. In these cases it must, however, be clearly understood that it is not to the watery discharge that we can trust for our diagnosis, but to the copious and prolonged bleeding.

“Thus far there is no difficulty. Not so, however, in the third class of cases, in which there is at first a discharge of blood only, neither copious nor prolonged, which is followed by a watery discharge, varying as to the time of its appearance—varying as to its quantity. It may be present within a very few hours after the accident—it may be profuse within a few hours after its appearance. These are the cases in which experience has of late proved that the diagnosis ought to be doubtful. The discharge of blood is certainly not of a character to warrant a diagnosis of fracture of the petrous bone; and as to the watery discharge, it is now well known that such a discharge may occur within a few hours after the accident, that its quantity may even be profuse, and yet there may be no fracture.”

I may be in error with regard to this matter, and yet it appears to me to be a very simple problem, at least as far as the existence or non-existence of a fracture is concerned. To determine the full extent of the fracture, is quite

another matter; although even here, as I have said before, it is easily possible to define rather coarsely the parts of the temporal bone affected. If we consider for a moment the solid, masonry-like construction of the temporal bone, we can scarcely resist the conclusion that, when a blow upon the top, back, or opposite side of the head is followed by any decided symptom whatever in the ear (as, for instance, bleeding, a watery discharge, or even simply pain), a fracture or a diastasis must have taken place in the corresponding temporal bone. A mere jar of the head is not competent to produce a hemorrhage from the external auditory canal. On the other hand, an actual stretching of the soft parts to such a degree as to tear one or more bloodvessels, is not, under such circumstances, physically possible in the vicinity of the drum-membrane, unless at the same time there shall have been an actual giving way of some part of the surrounding arch of bone. Such a laceration of the parts is sure to be followed by inflammation, and this inflammation will be proportionate to the degree of damage done to the parts. A profuse, and sometimes long-continued watery discharge from the middle ear, by way of the external auditory canal, is a well-known characteristic of an ordinary, non-traumatic, acute inflammation of the middle ear, provided that an opening has been established, either by natural or by artificial means, in the *membrana tympani*. In the severer cases of fracture of the temporal bone, the drum-membrane is very apt to be lacerated, and it is in precisely these severe cases of fracture that we encounter this symptom of a watery discharge from the ear. In estimating, therefore, the diagnostic value of a watery discharge from the ear, in cases of fracture of the temporal bone, I am disposed to go no farther than this: it affords a good measure of the degree of damage done to the temporal bone and contiguous parts. It is by no means necessarily a fatal symptom, for I have known several such cases to recover. I should perhaps not be justified in insisting that all of this watery discharge came from the middle ear and parts bordering upon it. Such, however, appears to me to be the more rational belief.

The treatment ordinarily employed to arrest an acute inflammation of the middle ear, is the treatment that can best be adopted for the relief of the inflammation caused by the fracture. I do not see why it may not, in certain cases, turn the scale in favor of recovery.

MISCELLANEOUS CONDITIONS OF THE EAR.

In our examinations of the ear, we often encounter conditions which in part represent the final results of some of the diseases described in the preceding chapters, and in part are quite distinct from those diseases. It is, therefore, simply as a matter of convenience that I bring some of the more important of them together here under the title of Miscellaneous Conditions.

ATROPHY OF THE MEMBRANA TYMPANI.—The *membrana tympani* may undergo atrophy through the operation of two very different causes; and, in harmony with these etiological differences, we may distinguish two well-marked types of atrophy. In one form, continued atmospheric pressure upon the outer surface of the membrane, without an equally great counter-pressure (also atmospheric) upon the inner side, produces a progressive, symmetrically distributed, and sometimes very marked atrophy of all its constituent parts. The inextensible, radial fibres of the *substantia propria* undergo absorption, in well-marked cases, and as a result we may find the drum-membrane spread out, like a thin film, over the long process of the anvil, the head of the stirrup, and the inner wall of the tympanic cavity. In the slighter grades,

the membrane simply appears to be more hollowed out or sunken than it should be, and, according to the degree of congestion of the mucous membrane of the middle ear, and to the presence or absence of fluid exudation in the drum-cavity, its color may be either of a reddish or purplish tone, or simply of a dark, greenish hue. Such a membrane, when inflated by Politzer's or Valsalva's method, will instantly change its entire appearance; becoming as convex, on the side towards the observer, as it before was concave. As the air engaged in the middle ear escapes by way of the Eustachian tube, we can see the membrane recede to or beyond its natural position. Another change will also attract our attention; the surface of the membrane, perfectly smooth and polished while in its sunken condition, becomes dull and sometimes even creased after it has been inflated. Sometimes, under too forcible an inflation, the membrane ruptures. Enlarged tonsils and a well-marked naso-pharyngeal catarrh are probably always associated with this condition of the membrana tympani. If we fail to find them, we may well doubt the correctness of our diagnosis. Such an atrophied drum-membrane is precisely like a newly-produced or "cicatricial" drum-membrane. It is now a well-established fact that the membrana tympani may, through the ulcerative action of disease, be totally destroyed, and then, afterward, upon the return of the region to a healthy condition, an entirely new membrane may be re-created. The latter, however, lacks the unyielding character of the normal drum-membrane, by reason of the fact that the inextensible radial fibres are not reproduced, except perhaps to a very limited degree. A careful inquiry into the previous history of the case can alone enable us to decide which of the two conditions is the one under observation.

In the second form of atrophy of the membrana tympani, the picture presented is markedly different from that observed in the form just described. The membrane occupies a perfectly natural position, or at all events it is not sunken sufficiently to attract our attention. It is remarkably transparent, however, and looks like very tightly-stretched parchment. Through its posterior superior quadrant, we can see distinctly the whitish mass of the end of the long process of the anvil. Below, a shadowy area, corresponding to the niche of the fenestra rotunda, attracts our attention. Anterior to these regions lies the apparently white and perfectly smooth promontory, or inner bony wall, of the tympanum. This whitish appearance is due to the fact that the mucous membrane, which should naturally conceal the whiteness of the underlying bone, has been reduced to such a state of thinness and non-vascularity that, to all intents and purposes, the bone lies exposed to view. The same wasting away of the mucous membrane takes place on the inner side of the drum-membrane, and thus renders it unusually transparent. The radial fibres do not participate to any marked degree in this atrophy, and consequently the drum-membrane retains its firm, unyielding character.

In the first form, our treatment should be directed to the naso-pharyngeal catarrh, upon which the atrophy of the drum-membrane depends. Until recently, I had always believed that a drum-membrane, which had once been allowed to undergo atrophy of its *substantia propria* through prolonged, undue atmospheric pressure upon its outer surface, would never afterward recover any material part of its inextensibility. I am quite sure now that under proper treatment, the effect of which shall be to remove undue atmospheric pressure upon the outer side of the membrane, it will slowly regain at least some of this valuable acoustic property. As far as the second form of atrophy is concerned, I know of no treatment that is likely to prove of any service whatever.

RUPTURE OF THE DRUM-MEMBRANE, from a blow upon the side of the head, or from a violent concussion of the air in the immediate neighborhood of the

ear, as when a gun or a cannon is fired, is a comparatively rare occurrence. No special treatment is required. The rupture usually heals promptly. If an acute inflammation follow the accident, it must be treated in precisely the same manner as if it had developed through the effects of a cold.

OTALGIA, that is, a pain in the ear not attributable to any discoverable lesion in either the middle or the external ear, is not an affection of common occurrence. I have seen only a few such cases, and in the majority of them I have found that the real cause of the pain was a decayed or ulcerated tooth. In these cases, the pain in the ear must be looked upon as a reflex nervous phenomenon. In a few instances I have known the pain to yield to quinine taken internally, and from this circumstance I have been disposed to consider the affection, in these cases, as a malarial neuralgia. It is probable also that rheumatism is sometimes to blame for these attacks of pain in the ear.

There are many other comparatively rare conditions and diseases of the ear, but as they are of minor importance, I must utilize the small space allotted to the subject of this article, in describing the nature and treatment of the more important affections of the organ.

AFFECTIONS OF THE AUDITORY NERVE.

The knowledge which we possess with regard to affections of the auditory nerve, is very scanty. This is due to various circumstances. In the first place, the auditory nerve, at all points throughout its course, is concealed from view. While the retina, or terminal apparatus of the optic nerve, lies comparatively near the surface of the body, and may be examined thoroughly by direct inspection upon the living subject, the *lamina basilaris*, with its delicate superincumbent structures, is solidly encased in bone, far beyond the reach of sight, and difficult to expose to view even in the cadaver. In the next place, we very rarely have the good fortune to examine, after death, the condition of an auditory nerve that has been believed to be diseased a short time previously. A few facts, however, have been ascertained in this manner, and others still have been learned by post-mortem examinations of the ear in individuals with regard to whose aural history during life nothing whatever has been known. Thus, for example, evidences of disease, in the shape of minute extravasations of blood, have been found in the brain, in the neighborhood of the rhomboid fossa, from which region the auditory nerve originates. New growths (syphilitic gummata, sarcomata, and carcinomata) involving the trunk of the auditory nerve, have been found at the base of the brain. Evidences of atrophy of the nerve-trunk have been observed. Extravasations of blood have been found in different parts of the labyrinth—in the vestibule, in the semicircular canals, and in the cochlea. The ring-shaped elastic membrane, which surrounds the foot-plate of the stirrup, has been found converted into an immovable, calcareous or osseous plate. Essentially the same changes have been observed in the secondary tympanic membrane which spans the inner end of the niche called the round window. These and other conditions have been observed after death, but unfortunately we can connect only a few of them with particular trains of symptoms observed during life. We are therefore obliged to infer what the condition of the auditory nerve is, in any given case, from the state in which we find the middle ear to be, from the manner in which the nerve performs its functions and in which the other organs lying near the auditory nerve perform theirs, from the presence or absence of certain constitutional symptoms, and finally from our knowledge of the lesions which may be found in the auditory

nerve proper, in its terminal apparatus, or in some part of the labyrinthine system of chambers. Such a diagnosis partakes necessarily of a speculative character, but in the present state of our knowledge we are prevented from reaching anything of a more definite character.

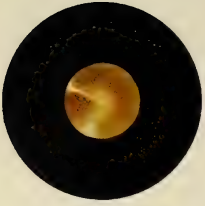
From time to time, we encounter cases in which the prominent symptom is a sudden or comparatively rapid loss of hearing in one or both ears. Inasmuch as a careful examination of all the accessible parts of the ear fails to reveal any lesions adequate to explain the deafness, and inasmuch as all sounds, whether transmitted through the bones of the skull or through the air, seem to be perceived only by the sound ear (in those cases in which the deafness is one-sided), we are accustomed to make the diagnosis of disease of the auditory nerve. In many of these cases we feel as if we might safely go a step farther, and locate the disease in that part of the auditory nerve which lies within the system of chambers called "the labyrinth." The temptation to do this is, I confess, very strong; but at the same time we must remember that our actual knowledge, whether pathological or physiological, does not justify us in making any such diagnosis.

The terms *Ménière's disease* and *apoplectic deafness* are applied to a group of symptoms of which the most prominent are a sudden loss of hearing (on one or on both sides, and usually complete), well-marked vertigo, inability to maintain one's balance, nausea, and tinnitus. In a case of this kind, Ménière found the different chambers of the labyrinth, at the post-mortem examination, filled with clotted blood. From that time to the present, it has been the custom to associate these lesions with the train of symptoms enumerated above; but whether correctly or not, I am not prepared to say. In a very small number of these cases, the hearing returns after the lapse of a few days, either to a large extent, or, more commonly, only to a slight degree. Leeching, counter-irritation behind the ear, and rest in bed, may accomplish some good, but as a rule no treatment is found to be of any use in restoring the lost hearing.

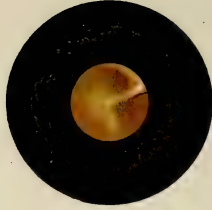
A second and very striking type of disease of the auditory nerve is that observed in the course of *constitutional syphilis*. The loss of hearing takes place gradually, though generally in from one to four weeks the deafness becomes almost or quite complete. The symptoms of dizziness, difficulty in maintaining one's balance, and nausea, are often absent, and when they are present, they are usually much less marked than they are in Ménière's disease. The prognosis is not favorable. Dr. Roosa, of New York, once succeeded, in a case of total deafness dependent upon syphilis, in restoring a large fraction of the hearing. I have repeated the same treatment—administration of iodide of potassium in increasing doses—in two or three cases, but it has not been my good fortune to restore more than a small part of the lost function. In one of these cases, I pushed the treatment with the iodide of potassium up to the point at which my patient took three hundred grains of the remedy, every day, for a period of several days.

There are various general diseases in the course of which the auditory nerve is believed to be seriously affected. All the infective fevers seem to predispose the patient to a sudden or rapid loss of hearing, without any demonstrable simultaneous affection of the middle ear. Epidemic cerebrospinal meningitis is particularly liable to induce a sudden loss of hearing, commonly in both ears. In these cases, it is a well-established fact that the inflammation at the base of the brain spreads to the labyrinth, and probably does the chief damage in the cochlea. The pathology of the loss of hearing which is occasionally observed in mumps, is much more obscure. The same is true of the sudden deafness which occurs after a confinement. In the great majority of all these cases treatment is of no avail, and the loss of hearing is permanent.

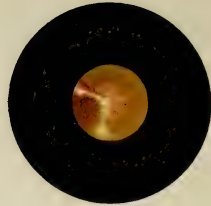
PLATE XXIX.



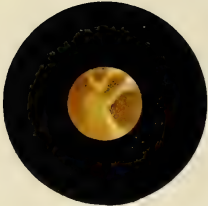
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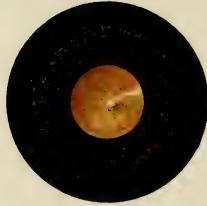
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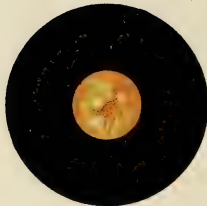
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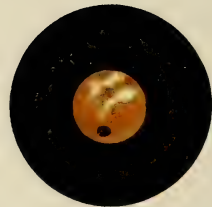
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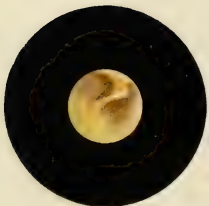
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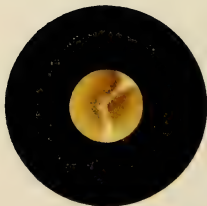
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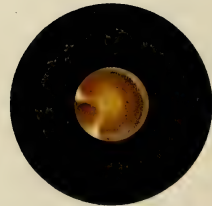
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12.

Copied from plates drawn by Prof. Adam Politzer, of Vienna
and published in his "Beleuchtungsbilder des Trommelfells."

H. BENCKE.

EXPLANATION OF PLATES REPRESENTING APPEARANCES OF MEMBRANA TYMPANI IN HEALTH AND DISEASE.¹

PLATE XXIX.

Fig. 1 represents a view of the normal membrana tympani (left ear), as seen by the light reflected from an unclouded sky in broad daylight. The lighter shade of color observed in the centre of the membrane, around the tip of the handle of the hammer, is due to the reflection of light from that portion of the inner wall of the tympanum which is called the promontory. This area of lighter coloring will vary in extent and intensity according to the distance of the membrane from the promontory, and also according to the degree of transparency of the membrane itself. The color of the remaining portions of the membrane may be described as a neutral gray. The handle of the hammer begins on the left-hand side of the figure, above the middle line, as a whitish-yellow knob, the "short process," and terminates at or near the centre (or "umbo") of the membrane. The so-called "bright spot" extends from this central point almost to the periphery of the membrane, a little in front (that is, to the left) of the median line of the figure. In shape it is a well-defined triangle, whose base corresponds with the periphery of the membrane. It is produced by the reflection of light from a polished surface, and whatever other significance it may have, it certainly furnishes a valuable criterion by which we may judge of the state of nutrition of the membrane.

Fig. 2 represents a normal membrana tympani belonging to the right ear. The more solid tissues which fill the gap between the neck of the hammer and the spina tympanica posterior, and which are commonly known as the "posterior fold," are represented here. They begin at the "short process," and run backward (that is, to the left) in the shape of a sickle, along the upper boundary of the membrane. The halo-like reflection from the promontory is less marked than in Fig. 1, and the bright spot does not extend quite to the periphery of the membrane.

In the case from which Fig. 3 was taken, an oil lamp was used for illuminating purposes. Hence the reddish-yellow hue of the membrane. The delicate red line which forms the posterior limit of the handle of the hammer, represents a congested condition of what are technically known as the "manubrial vessels." These vessels, which are considerably larger than any of those which traverse the membrane proper, are the first to respond to any irritation of the adjacent auditory canal, or to show the effect of pressure (such as a speculum is apt to produce) upon the efferent veins of this part of the ear. It will also be noticed that the "bright spot" is interrupted midway between the "umbo" and the periphery of the membrane.

The membrane pictured in Fig. 4 is classed by Prof. Politzer with the three which precede it, as a normal, but unusually transparent, membrana tympani. The triangular figure seen to the left of the handle of the hammer is made up in part of the lower portion of the long process of the anvil (the whitish line which runs in a direction parallel with that of the handle of the hammer), and in part of the posterior arm or limb of the stirrup (the more delicate whitish line which runs in a direction continuous

¹ These illustrations are copied, by permission, from the admirable colored plates drawn by Prof. Adam Politzer, of Vienna, and published in his well-known work "Die Beleuchtungsbilder des Trommelfells im gesunden und kranken Zustande" (Wien, 1865).

with that of the "bright spot"). The anterior limb of the stirrup is concealed behind the long process of the anvil.

It is quite possible that at the present time—these colored drawings were made twenty years ago—Prof. Politzer might feel disposed to interpret the appearances presented in this figure as indicating a condition of atrophy (from sclerosis), rather than one of normal, though unusual, transparency of the membrane. The absence of an unusual whiteness of the inner wall of the tympanum is the only feature which seems to me to be lacking, if my supposition is correct.

Fig. 5 represents a markedly congested, but otherwise only slightly altered, membrana tympani, such as is commonly seen in the early stage of an acute catarrhal (non-purulent) inflammation of the middle ear. The chief redness is noticed along the handle of the hammer (manubrial vessels), and near the circumference of the membrane (peripheral vessels). In the intermediate space between the manubrial and the peripheral vessels, may be seen a few superficial ones, which serve as connecting links between the two systems.

In Fig. 6, the inflammatory changes are represented as having gone a step further. The epidermoid surface is less polished (commencing serous infiltration), and ecchymoses may be seen at several points, especially between the handle of the hammer and the posterior periphery of the membrane.

Figs. 7 and 8 show an advanced stage of inflammation of the membrana tympani. The parts are so much swollen and gorged with blood that the handle of the hammer can no longer be distinguished. Masses of desquamating epithelium, infiltrated with pus, appear like irregularly shaped patches of a reddish or yellowish-white color upon a purplish or bright red background. In Fig. 7, a process of granulation has raised the tissues of the membrane into low prominences. In Fig. 9, the circular dark spot in the lower part of the inflamed membrane represents a sharply cut perforation.

In Fig. 10, the following peculiarities should be noted: the marked foreshortening of the handle of the hammer, its tip at the umbo being somewhat indistinct, while the short process, which lies nearer to the observer's eye, is unusually prominent and well defined; and the decided prominence of the posterior fold.

The grayish-white margin at the periphery of the membrane represented in Fig. 12, corresponds to the annulus cartilagineus, or that portion of the membrana tympani which fits into the sulcus tympanicus. The grayish-white color is probably due to the presence of fat cells. Politzer compares it to the arcus senilis of the cornea. The free portion of the membrane in this figure seems to be unnaturally curved inward.

PLATE XXX.

The different figures in this plate represent the lesions which often remain after the subsidence of a purulent, destructive inflammation of the tympanum.

In Fig. 2, the appearances are as if the greater part of the right membrana tympani had been destroyed. The white circular spot above and to the right, represents the short process of the hammer, whose very much foreshortened handle runs (in the drawing) downward and backward until it seems to touch the exposed inner wall of the tympanum. A thickened remnant of the original membrane is still attached to the handle of the hammer. It somewhat resembles in shape a new moon. The rounded surface over which two or three bloodvessels may be seen to ramify, represents either the mucous membrane of the inner wall of the tympanum, or a thin reproduction of that part of the drum membrane which ulceration has destroyed. In the latter case, as the newly-formed membrane would be closely applied to the inner wall of the tympanum, mere ocular inspection would scarcely suffice to determine accurately the true relations of the parts.

Fig. 3 represents an ear (left side) from which the greater part of the membrana tympani has been removed by disease. Anteriorly (that is, toward the left) a whitish,

PLATE XXX.



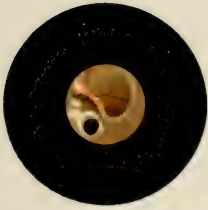
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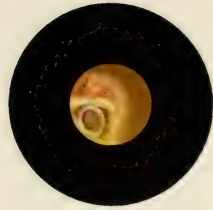
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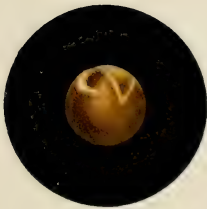
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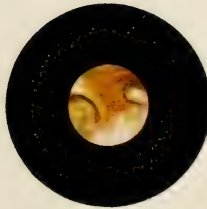
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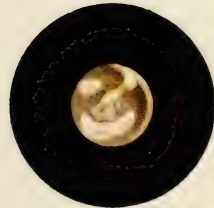
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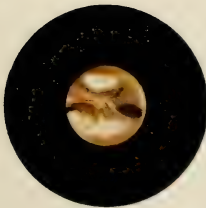
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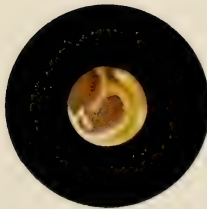
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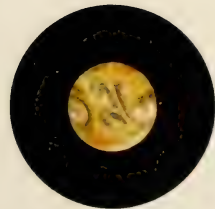
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Copied from plates drawn by Prof. Adam Politzer, of Vienna,
and published in his "Beleuchtungsbilder des Trommelfells."

H. HENCKE.

thickened remnant, representing about a third of the entire membrane, still remains *in situ*. The hammer has probably been destroyed, but the familiar, triangular figure, which represents the long process of the anvil and the posterior limb of the stirrup, may still be seen in the upper part of the drawing. Enlarged bloodvessels traverse the promontory. Below and to the right, will be observed a sharply outlined excavation, which represents the niche for the round window (*fenestra rotunda*).

In Figs. 5 and 6, the evidences of former perforations are easily recognized, the newly-formed membranes, or "cicatrices," as they are technically called, being thinner and more transparent than the surrounding, original *membrana tympani*. In Fig. 4, the lower perforation still remains open, and its thickened edges seem to have undergone calcareous degeneration. Two other small patches of calcareous material lie between it and the short process of the hammer. The upper and much larger perforation appears to have healed by cicatricial new-formation of membrane.

Fig. 7 represents one of two conditions, viz., either a highly atrophied and sunken *membrana tympani*, or one which has been entirely reproduced after total destruction. The picture presented would be the same for either condition. The handle of the hammer apparently presses with its tip against the tissues of the promontory or inner wall of the tympanum. The deep shadow between the handle of the hammer and the posterior fold, shows how atmospheric pressure or adhesions have forced this part of the membrane far inward beyond the plane which it naturally occupies.

Extensive calcareous deposits are shown in Figs. 9, 10, and 11. Extensive thickening, with still lingering inflammatory action, may be seen in Fig. 8. In Fig. 12, healing seems to have taken place despite extensive proliferative and destructive processes. In the midst of the ruins, the handle of the hammer is barely recognizable.

DISEASES AND INJURIES OF THE NOSE AND ITS ACCESSORY SINUSES.

BY

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INTRODUCTION : DESCRIPTION OF INSTRUMENTS, ETC.

THE direct, visual examination of the nasal passages and upper pharyngeal space, first undertaken and rendered possible, by means of his "light-conductor," by Bozzini, was an obsolete art until amplified and rendered readily practicable by the genius of Czermak, and still further elaborated and better utilized, both from a pathological and therapeutical standpoint, by Fraenkel and Michel, and especially by Voltolini and Zaufal. The method introduced by Czermak is that generally employed to-day, the innumerable modifications which represent the inventive ingenuity of many specialists yielding upon practical trial to the more simple, yet fully as efficient, method and apparatus of the first-named operator. Complete *rhinoscopy* consists in both the direct inspection of the nasal passages anteriorly, through the nostrils held dilated by means of a suitable speculum, and the examination of the posterior portions of the same passages, the supra-palatine walls and their contents, the posterior surface of the velum, and the upper pharyngeal space, with the necessary aid of a small mirror which is introduced through the mouth, and which is held in a position midway between the relaxed soft palate and the posterior pharyngeal wall. The former method may properly be designated *anterior rhinoscopy* and the latter *posterior rhinoscopy*, or, more exactly, *pharyngo-rhinoscopy*.

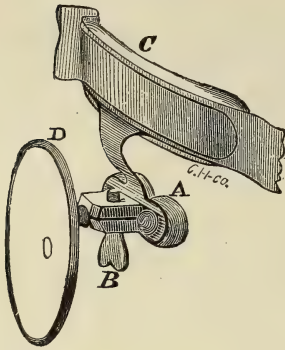
INSTRUMENTS FOR EXAMINATION OF THE NASAL CAVITIES.—These are but few and simple: (1) A forehead reflector and (2) an argand gas-burner, or some equally efficient source of illumination; and in addition, for anterior rhinoscopy, (3) a nasal speculum; and for the posterior examination, (4) a small mirror and (5) a tongue spatula.

The *forehead reflector* is a round, slightly concave mirror, either three and a half or four inches in diameter, with a perforation in its centre, or with the glass simply left unsilvered at that point. Its focal distance should be about fifteen inches. It is attached either to an elastic headband, with ball-and-socket support (Kramer), or to a spectacle frame (Mackenzie), and may be worn over either eye, or upon the forehead; the former method is the more correct one, and the right eye is to be preferred.

Illumination.—The form of "light" apparatus that shall be employed depends upon the choice of the surgeon; this may have a wide range, for the

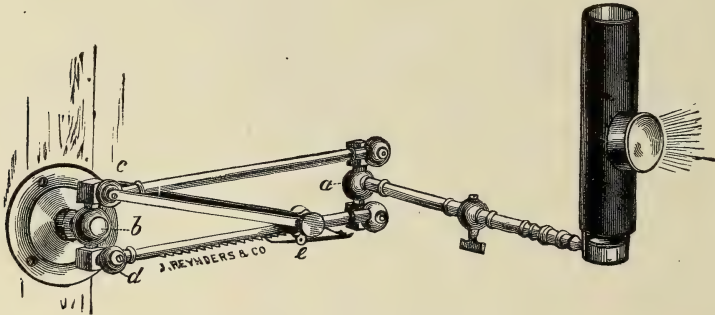
varieties are legion; but the basis of each is the same, and they vary only in their nature, their details, and the number of condensing lenses that are used to intensify their illuminating power. For ordinary purposes, there is no better nor more convenient light than that which is furnished by the argand gas-burner, mounted upon a drop-light or stand, which permits of the flame being lowered or elevated at will, or upon the arm of a gas bracket fastened to the wall. Such a light certainly is easily procurable, and at a slight cost if gas is obtainable; if not, as in the country, the ordinary lamp known as the "student," which burns petroleum or oil, forms a very efficient substitute. It is no difficult matter to attach to either of these lights a single plano-convex lens, two and one-half inches in diameter, which fits into the metallic tube or chimney known as Mackenzie's, if it be deemed desirable to intensify their illuminating powers, as will probably be the case when it is remembered that the light for rhinoscopy should necessarily be more intense than that used for laryngoscopy, and that sunlight is here unavailable.

Fig. 966.



Forehead reflector.

Fig. 967.



Illuminating apparatus for rhinoscopy.

Nasal specula exist in great variety. The forms here figured will be found to be the most efficient, as well as the most recent. Fraenkel's possesses the

Fig. 968.

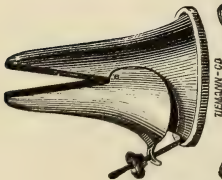
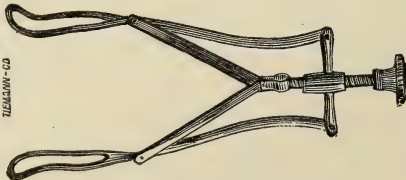
Robert and Collin's
nasal speculum.

Fig. 969.



Fraenkel's nasal speculum.

Fig. 970.

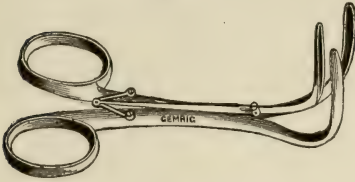


Nasal speculum.

advantage of allowing the dilatation of both nostrils simultaneously. An ordinary ear speculum answers a good purpose in children. Zaufal has

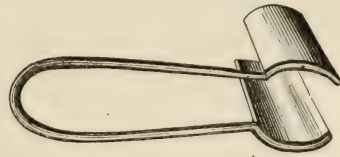
devised a long tube of metal or hard-rubber, ending in an expansion similar to that of the ear speculum (3–7 mm. in diameter, and 10–12 cm. in length), by means of which, when it has been introduced into and through the nasal

Fig. 971.



Eisberg's nasal speculum.

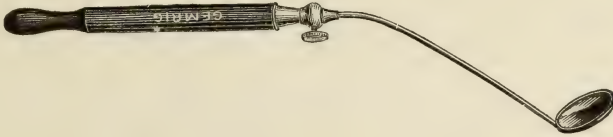
Fig. 972.



Thudichum's nasal speculum.

passage, the pharyngeal orifice of the Eustachian tube and the posterior wall of the pharynx become visible. Voltolini, Tröltzsch, Roth, and others, use a double-bladed metal speculum, in which, after introduction, the blades

Fig. 973.

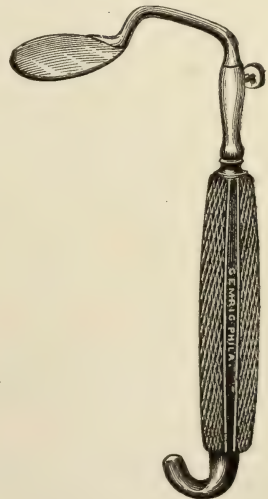


Rhinoscopic mirror.

are separated by a screw arrangement at the handle. Schnitzler has modified this instrument by making longitudinal openings along the blades, to permit a lateral inspection. Elsberg uses a trivalve speculum similar to the tracheal dilator of Laborde; Thudichum, one in which two narrow metallic blades are separated by the resiliency of a bowed spring of wire, which holds them attached to each other. It is well adapted to facilitate operations upon the nasal passages. Finally, a hook, a bent hair-pin, a probe, or some equally simple instrument often suffices, by pulling the wing of the nostril aside, to allow of a good view being obtained of the deeper parts of the passage.

Rhinoscopic Mirror.—Specially constructed mirrors are not necessary for rhinoscopic purposes, though many have been devised. Those of Fraenkel, Voltolini, Mackenzie, and Störk, are perhaps the best known, but the combination of tongue spatula and mirror that exists in some of these, is inconvenient and often impracticable, and the same may be said of the apparatus of Duplay, which aims to combine a retractor for the soft-palate with the mirror. The ordinary rhinoscopic mirror resembles precisely that used for laryngoscopic examination, except that it is usually smaller, and that the glass stands at nearly a right angle to the shaft, or that this is bent somewhat in the form of an italic *S* (Lennox Browne). The glass is circular, is covered with amalgam posteriorly, has a plane reflecting surface, and is set in German silver. Its

Fig. 974.



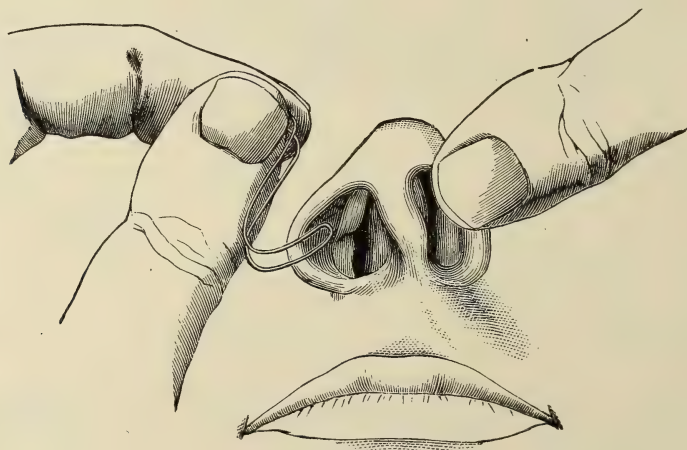
Türk's tongue spatula.

diameter is half an inch, and its thickness one-twentieth; to it is soldered, at the nearly right angle described, a partly flexible, and preferably a straight shank of metal, which terminates in a convenient handle, where it can be lengthened or shortened at will by means of a screw. The size of the mirror that should be used in a given case, depends entirely upon the amount of space existing between the patient's relaxed velum and the posterior pharyngeal wall. This will be found to vary greatly, but, as a rule, the small mirror described is the most practical.

Tongue Spatula.—The tongue spatula modelled after the pattern of Türk is well adapted to fulfil its purpose.¹

ANTERIOR RHINOSCOPY.—The position of the patient, of the surgeon, and of the source of illumination, do not vary from those necessary for laryngoscopy; that is, the patient is seated erect, in a straight backed chair, with his head thrown slightly backward; the surgeon, seated in front of him, so adapts the position of his head, upon which he has fastened the concave forehead reflector, as to place it on a level with that of the patient, and then looks directly forwards through the perforation in the mirror, with his right eye, towards the latter's nose; the rays of light, as they come from the lamp which is placed upon the right of the patient, at the level of his ear, are then caught upon the forehead reflector, focused, and thence reflected forwards into the nasal speculum, which is now introduced into the nostril of the patient, care being taken not to pass it too high up into the narrow space between the cartilaginous septum and the outer bony wall of the nostril, where it would cause pain. Its blades are next dilated or separated, and the focus of light is carefully thrown between them and into the nasal passages; the parts of the latter now come into view, and will be seen to vary in their normal configuration, and likewise according to the nature and degree

Fig. 975.



Anterior rhinoscopy.

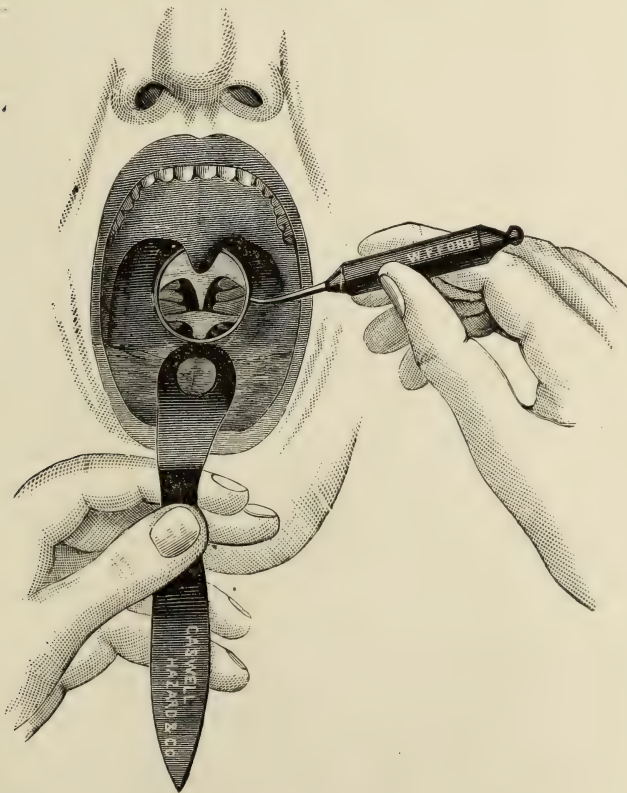
of their diseased condition. Ordinarily the anterior, and parts of the inferior, surfaces of the two lower turbinated bones, the side of the septum, and the

¹ See also Baginsky (Rhinoscopic methods of examination and operation), Volkmann, Klin. Vorträge, No. 160, 1879; Harrison Allen, Aids to Diagnosis in Nasal Diseases, Phila. Med. Times, 1880-1, vol. xi. p. 613; Voltolini, Rhinoskopie und Pharyngoskopie. Breslau, 1879; and Schnitzler, Laryngoskopie und Rhinoskopie. Wien, 1879.

inferior meatus are distinctly visible, the extent of the view of the two latter depending, however, upon the natural formation of the parts; for it is exceedingly common to find a deflection of the septum nasi to one side, usually the left, narrowing more or less the respective naris, occasionally occluding it, and preventing all view of the deeper parts. On the other hand, cases are met with in which a very wide and roomy meatus permits of a view directly through it into the pharynx, and of the pharyngeal orifice of the Eustachian tube.

POSTERIOR RHINOSCOPY.—For the purposes of the posterior examination—to illuminate and convey to the eye the picture of the upper pharyngeal space, the posterior nares, and more or less of the posterior portions of the nasal passages themselves—the position of the patient and surgeon, and the direction and method of employing the light, are the same as for anterior rhinoscopy, with two exceptions: first, that the focal point of light is to be thrown into the open mouth, and on the base of the uvula; and second, that the patient, with widely opened mouth, allows the tongue to lie quietly behind the lower incisor teeth, and depresses it well down upon the

Fig. 976.



Posterior rhinoscopy.

floor of the mouth with the spatula or depressor. The rhinoscopic mirror having been warmed, is now carefully introduced from the corner of the mouth, with its reflecting surface upwards, carried over the tongue to one side or other of the uvula, until it passes beneath the motionless velum, and

stands midway between it and the posterior pharyngeal wall, touching neither, and at an angle of about 130° . In this position, it will be impossible to obtain the whole picture of the parts at once, except in exceptional instances; and the face of the mirror must therefore be turned from side to side, to view the lateral pharyngeal walls; upwards, to view the vault of the pharynx; and at more or less different angles and inclinations, to see completely the parts embraced within the posterior openings of the nares.

Such is the method; and a complete examination is almost always practicable, though comparatively seldom with the facility which attends the use of the laryngoscopic mirror. Three difficulties may present themselves to prevent the examination. One is insuperable—a long hard palate which approaches so nearly to the posterior pharyngeal wall, that there is no practicable degree of space left through which an examination can be effected. A second is common, and may require an additional instrumental procedure; this condition is that in which a long, broad soft palate, a long uvula, and a short distance between them and the posterior pharyngeal wall, coexist, and in which an examination can only be made when the former are drawn away from the latter. This can be accomplished by means of the so-called palate hook, made of metal, or, still better, a broad, well-curved hook of hard rubber, or a bougie with a wire centre to give the necessary firmness. The latter are much better tolerated than the former; they are introduced by the left hand gently under the palate (the right hand holding the mirror), and the palate is then drawn with moderate force towards the operator—that is, away from the posterior pharyngeal wall. This procedure rarely succeeds, however, at the first trial, though successive and persevering attempts will generally end in tiring the palatine muscles or in training them to a point of toleration, and will thus overcome the spasmodic contraction which at first follows any attempt to draw the velum forwards. As a rule, however, it will be found, that the same time that is devoted to training the patient to tolerate this hook, or any of the other forms of instrument that have been devised (Türk, Lorry, Störk), will be all-sufficient to train him to breathe quietly through the nose, and to cause the palate to hang immovable in the mouth. The third and last difficulty exists at first in the majority of cases. It is caused by the drawing up of the velum and uvula tightly against the pharyngeal wall, as soon as the patient opens his mouth and places the spatula upon the tongue, or when instruments are about to be introduced by the examiner. Quiet respiration, carried on through the nose, will overcome this difficulty, however, at once, when the velum will be found to hang motionless and free from the pharyngeal wall. If the patient cannot succeed in maintaining respiration through the nose, the palate may be made to fall forwards by causing him to emit certain nasal sounds, such as the French *en*. The first plan is however the best; the examination is then to be made with celerity, accuracy, and completeness.

Reflex irritability of the pharyngeal parts, it may here be remarked, is a far greater disadvantage than when it occurs as an impediment to laryngoscopy. A skilful and certain hand, with some training of the parts, will do much to facilitate the examination.

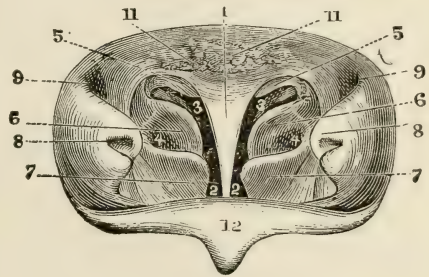
I believe that it will rarely be found necessary for the purposes of examination alone, though it may be for operative procedures, to acquire absolute control of the soft palate, or a wider patency of the palato-pharyngeal space, by *tying the palate forwards*, as advised by Störk and more recently by Wales. This procedure consists in passing a cord through each nostril to the pharynx, drawing the ends out through the mouth, passing them over the ear on each side, and tying them behind the head, the soft palate yielding under gentle traction, and being folded, as it were, upon itself. Bosworth suggests that a

linen cord, stiffened with mucilage, or a piece of catgut, might be passed in the same way, but more conveniently, by means of a small catheter shaped like that used for the Eustachian tube. The ends of the cords are tied by a surgeon's knot of three turns, over the upper lip, or are held by an ingenious little clamp devised by Jarvis. The operation should be performed quickly and skilfully, when it is fairly well tolerated by the patient.

The Rhinoscopic Image.—As the mirror is passed into position behind the velum, the first object which attracts attention is the posterior surface of the uvula, and the next the posterior surface of the velum, a broad, reddish expanse, which arches upwards so as to cut off from view, in the majority of instances, more or less of the inferior portions of the nares proper, and thus partly hides the posterior extremities of the inferior turbinated bones. The septum nasi now comes into view, and as it is the most easily recognizable of all the parts, it serves as a landmark or guide for the rhinoscopic picture, as the vocal cords do for that of the larynx. It is a thin, sharp ridge, whitish in color, and its sides are readily seen for some distance; above, it widens, becomes of a deeper color, and merges into the parts which go to make up the vault of the pharynx. To either side of it are seen dark, ovoid openings, the posterior nares, which are more or less occupied by the three turbinated bones, bulbous bodies of a gray or ashy-red color. The middle one, with part of the middle meatus of the nose, is the most distinct. Parts only of the superior and inferior bones are visible; the former appears simply as a narrow projection from the outer wall of the nasal fossa, extending downwards, inwards, and backwards, to lose itself behind the middle turbinated bone; the inferior, which overlaps the middle bone, and the upper portions of which alone are visible, appears as a rounded, hard tumor, with an irregular and grayish colored surface. Of the meatuses of the nose, the middle is the most distinct, the upper appearing only as a dark line or depression, while the inferior is only occasionally seen. About the level of the inferior turbinated bone, further towards the sides of the picture seen in the mirror, and upon a different plane, is seen on either side a rounded, smooth projection, of a bright-red color. This is continuous below with two sharp, elevated ridges of mucous membrane, the anterior of which contains the fibres of the levator palati muscle, which pass downwards and inwards to the dorsum of the velum, where they are finally lost. These are the pillars of the pharyngeal orifice of the Eustachian tube, the rounded mouth of which lies between them at the point where they leave the rounded protuberance above mentioned. If this latter be followed upwards, backwards, and outwards, it will be seen to bound and define a deep groove, which lies between it and the plane of the posterior pharyngeal wall, the fossa of Rosenmüller.¹

If the inclination of the mirror be now changed to a more obtuse angle, or if use be made of one mounted at the laryngoscopic angle, the domelike cavity of the vault of the pharynx will be brought into view. This presents an irregular outline, resembling a glandular structure upon its surface, and extends downwards towards each Eustachian orifice in a series of usually

Fig. 977

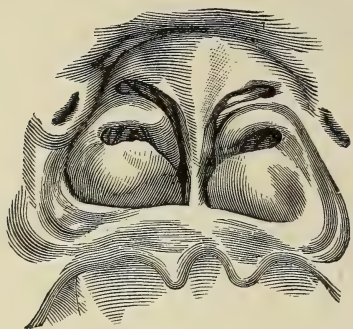


The rhinoscopic image.

¹ It should be borne in mind that Fig. 977. is necessarily somewhat diagrammatic. Fig. 978 represents the parts of the posterior nares more as in reality they appear.

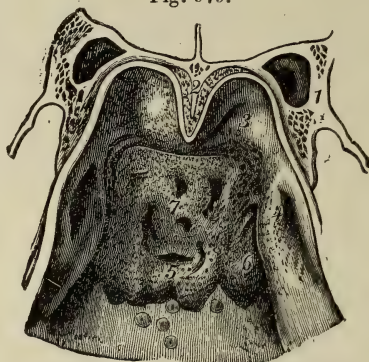
longitudinal furrows and ridges—the adenoid tissue of the vault, or pharyngeal tonsil of Luschka. As this tumefaction—marked in some cases, absent in others; frequent in children, rare in adults under normal conditions—merges gradually into the smooth surface of the posterior pharyngeal wall,

Fig. 978.



The rhinoscopic image.

Fig. 979.



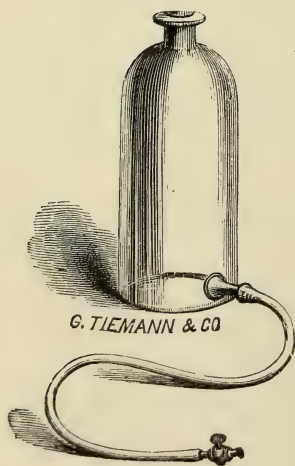
Vault of the pharynx as seen by posterior rhinoscopy.

it can no longer be traced; the mucous membrane of the latter, deep-red, smooth—with the exception of an occasional follicle—and shining, supplants it.

INSTRUMENTS FOR TREATING THE AFFECTIONS OF THE NASAL CAVITIES.—The instruments employed for the preliminary cleansing of the nasal passages being, in many of their diseases, identical with those required for their subsequent medication, their general consideration at this point will be conducive to both brevity and clearness.

Instruments and Methods of Cleansing.—The best known apparatus, certainly the one most widely used to-day, is the so-called nasal douche of Weber and Thudichum, either in its original form or in one of its many modifications. Without entering into a discussion of its possible merits and positive disadvantages,¹ and while questioning, upon the basis of a practical, clinical experience, the reality of the dangers to the middle ear from its use, which have been so vividly pictured by Moos, Roosa, Knapp, and others, I must record my conviction that it is an inefficient instrument for the purpose for which it was designed, inasmuch as it does not thoroughly wash or cleanse the nasal cavities even when carefully used. This assertion is readily substantiated by observation, and I may even add that its very general employment by the laity, unguided, too often, by professional advice, is productive of much harm; that even apparent, temporary good effects ultimately fail; and that the use of strong saline solutions in large quantity, and passed through the nares under high pressure in a divided or interrupted jet or stream, is not unfrequently an efficient factor in the propagation. if not in the causa-

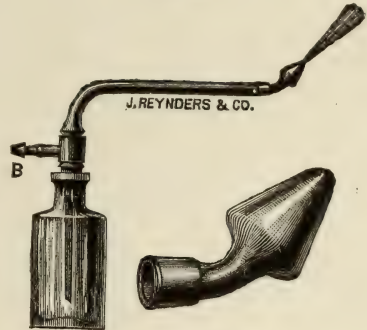
Fig. 980.



Nasal douche.

tion, of a chronic inflammation of the delicate nasal mucous membrane, with its usual result of permanent infiltration of the mucous and submucous layers, rather than a means of its relief. With Robinson, I believe that the employment of these instruments should be restricted, if used at all, to exceptional cases of very aggravated catarrhal inflammation, with accumulation of pent-up and hardened secretions; and that even here the posterior nasal syringe answers a better purpose. In ordinary catarrhal disease the douche is never required. In my practice, the use of the nasal douche has been entirely superseded by that of an instrument made of hard rubber, fashioned in an effective and convenient form, and so arranged as to throw a powerful *coarse* spray. This apparatus, I, and others with me, have found, upon extended trial, to be efficient, agreeable to the patient, less painful than the douche, and devoid of all possible danger. With it, the entire nasal passages and upper pharynx may, except in exceptional instances, be thoroughly cleansed of crusts and secretions by the use of less than one ounce of the medicated fluid in spray. (The latter principle is an essential one, in the nature of the apparatus.) This instrument should be used, proper indications existing, according to the following rules, which are to be given to the patient, to insure its efficient employment on his part:—

Fig. 981.



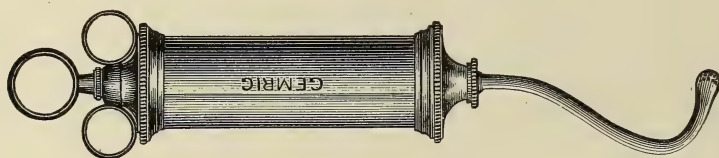
Nasal spray apparatus.

1. Warm the medicated fluid in the bottle before using, by holding the filled bottle for a few moments in hot water.
2. Hold the body erect and incline the head very slightly forward over the toilet basin.
3. Introduce the conical nozzle of the apparatus into the nostril (first on the side most occluded), far enough to close it perfectly, holding at the same time the horizontal tube of the apparatus directly outwards from the face; do not turn it from side to side, or downwards; make a trial of the spray by compressing the hand ball once, to prove that the opening in the nozzle is not occluded in the nostril, and then—
4. Open the mouth widely and breathe gently, but quickly through it in a snoring manner; avoid carefully all attempts at speaking, swallowing, or coughing; at the moment that the fluid passes into the upper part of the throat from the nostril being operated upon, a desire to swallow will be experienced—resist it—and the next second the fluid will pass forwards through the opposite nostril.
5. Hold the end ball of the apparatus firmly in the right hand (the left holds the bottle) and *operate it briskly*, until the spray of medicated fluid, which should be felt at once to enter the nasal passage, has passed around it and appears at the opposite nostril; stop at this moment.
6. Remove the nozzle from the nostril, allow the surplus fluid to run out of the latter, and blow the nose gently. *Never vigorously.*
7. Repeat the operation upon the opposite nostril.

Various cleansing solutions may be used in the apparatus; one of the best is as follows: *Acidi carbolici*, ℥j (this quantity is often necessarily varied to suit the susceptibility of different mucous membranes); *sodii bicarbonat.*, *sodii bicarb.*, āā ʒj; *aquæ rosæ*, *glycerinæ*, āā fʒj; *aquæ ad* Oj. Or still better, *sodii bicarbonat.*, *sodii bicarbonat.*, āā ʒss; “*Listerine*,” fʒj; *aquæ ad* fʒiv. Where a much larger quantity of a cleansing solution is necessarily used, as with the anterior or posterior nasal syringe, simple warm water, with the addition of borax, ten grains to each ounce—or “*Listerine*,” in the proportion of one part

to from two to ten of warm water—will answer the purpose well. Sometimes, when the disagreeable odor is strong, I use, after a thorough syringing with one of these alkaline solutions, a spray of equal parts of “Listerine” and water; it destroys fetor very quickly, and substitutes for it the pleasant odor of thyme. It will be noticed that I use no sodium chloride in any of these cleansing solutions. I believe that it does more harm than good; that the saline solution favors endosmosis as it passes over the nasal mucous membrane, and therefore increases rather than diminishes intra-nasal swelling. Many other formulæ will suggest themselves, as, for instance, *Glycerini acidi carbolici*, f3jss; *sodii biborat.* 3j; *aquæ.* ad Oj. *Liquoris potassii permanganatis*, f3jss; *sodii biboratis*, 3j; *aquæ.* Oj. *Acidi salicylici*, gr. x; *sodii bicarbonatis*, 3j; *aquæ.* Oj. All solutions, whatever their nature, should be at about blood heat when used. In the severer forms of nasal disease—those attended by the formation and firm impaction in the passages of hard, dense crusts—as in simple and syphilitic ozæna, atrophic and fetid catarrh, and the like, the use of the spray apparatus will not be sufficient to dislodge these, in the first instance, and a more powerful means (short of direct instrumental removal) must be employed. This may be best obtained by the posterior nasal syringe, of hard rubber or metal, which is used to cleanse the parts posteriorly by way of the pharynx and posterior nares; or by means of a suitably curved hard-rubber tube used in the same way, its terminal extremity

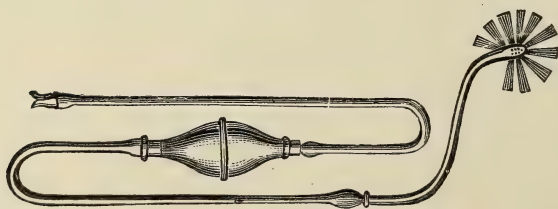
Fig. 982.



Posterior nasal syringe.

being pierced with coarse perforations, presenting forwards when the instrument is in place; or, perhaps, with a slit sawn transversely, so as to give a fan-like stream, and this fastened to the well-known double hand-ball rubber

Fig. 983.



Posterior nasal tube fitted to Davidson's syringe.

tube of the Davidson apparatus. For the anterior nares, the ordinary hard-rubber syringe of the aurist answers the purpose.

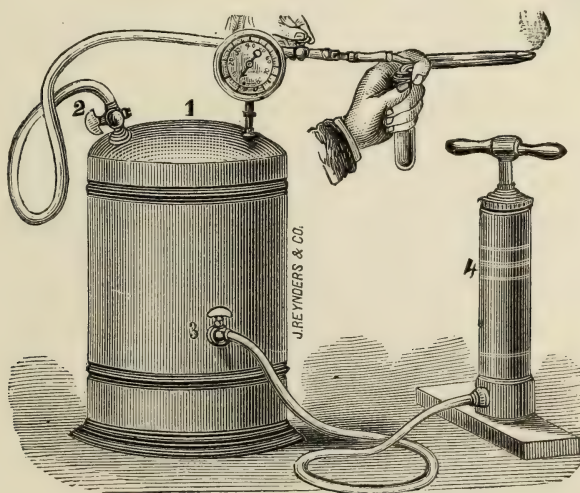
METHODS AND INSTRUMENTS OF MEDICATION.—If I exclude, for the moment, the use of caustics and of surgical measures in the management of catarrhal conditions of the nares, the treatment is based both clinically and practically either upon the employment of various medicated fluids, used in *spray* by

means of some form of atomizer, or upon the use of *medicated powders*, applied with the anterior or posterior nasal powder-insufflator, in its various forms. Both methods have their warm advocates, and both are now extensively employed, and properly so, to the exclusion of the older and much less efficient methods of medication in the treatment of nasal disease. My own experience prejudices me strongly in favor of the spray. I believe that with a proper spray-tube, and with a pressure of compressed air of 40 pounds or more to the square inch, no more perfect application can be made to the parts. This should always be, if possible, through the posterior nares, the spray being driven forwards through the nose; and to insure completeness, the velum of the patient must be held forwards, by means of a suitably curved hook in the operator's left hand, in order that space may be afforded through which to throw the spray. This procedure I regard as absolutely essential, in order to secure a complete application.

Atomizers or spray producers are constructed upon two principles, both familiar to the profession, and too well known to require an extended description. A type of the first class is found in the atomizer of Richardson; and of the second, in that constructed upon the principle of Bergson; of both, modifications, mainly in form, exist, the principle remaining the same.

The most convenient and most efficient apparatus is that here figured; but

Fig. 984.

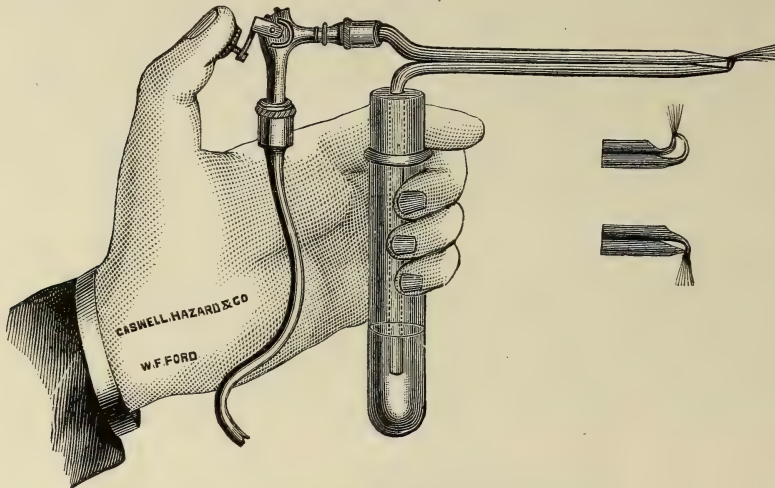


Compressed-air atomizer, or spray-producer.

its cost, though this has recently been materially lessened, may prove an obstacle to its introduction into the *armamentarium* of the general practitioner. It consists of a metal air-receiver, an air-pump, and glass atomizing tubes, curved so as to throw the spray upwards (posterior nares), downwards (larynx), and backwards (pharynx), together with the necessary connecting rubber tubes. The cylinder having been filled with compressed air up to a pressure of from 40 to 60 pounds to the square inch, as shown by the indicator, the spray-tube, with its proper end immersed in the medicated fluid contained in the small vial or test-tube, is held in the right hand, and the pressure of the air, which is now allowed to pass by turning the small cock upon the tube with the other hand, is controlled by the right thumb of the operator, pressed upon the end of the glass tube so as to compress the rubber pipe at this point. It is thus under complete control, and the spray can now be

caused to pass instantly in a stream, or in small jets, regulated exactly as to amount, at the will of the surgeon. The rubber tubing from the cylinder is usually made to fit to that on the glass atomizers by means of a bayonet-joint, but the more elaborate device here shown (Fig. 985) may be employed.

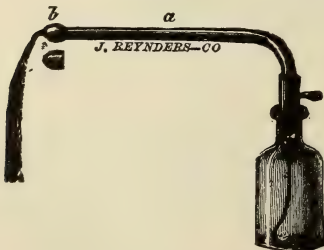
Fig. 985.



Spray-tube with patent cut-off.

In default of this apparatus, the ordinary hard-rubber atomizers, constructed upon the principle of either Richardson or Bergson, may be used with good effect. In both, the propelling power is developed by the use of the hand air-bulbs. These should always be double; a single air-bulb gives but an intermittent current of spray; the addition, between the hand-bulb and atomizer, of a second and more elastic one, which becomes distended, by exerting a continuous pressure will furnish a steady and constant stream. The hard-rubber tube of the instrument is provided with three separate tips, arranged to throw the spray in the directions necessary; and its main disadvantages are, the length of time that it takes to develop the propelling power by means of hand-ball pressure, an important point when the

Fig. 986.



Atomizer throwing spray downward.

Fig. 987.



Another form of atomizer.

instrument is in position in an irritable throat, and the fact that the current of spray is not absolutely and quickly under the control of the operator. As a rule, then, the application with this instrument

will have to be made through the anterior nares, the spray being driven well back into the pharynx.

Other simpler and less costly spray producers are now made in great variety, upon the plan of Bergson, and as they are furnished with metal tubes of various lengths and directions, and are easily procurable, they play a useful part in the treatment of nasal and pharyngeal diseases.

Powder Insufflators.—The most useful forms are shown in the following cuts. One is arranged (Fig. 988) to deliver a charge of the finely pulverized powder with which the bottle is charged, into the anterior nares (Smith), and the second (Fig. 989), with a longer, curved tube, performs the same operation in the posterior nares. (Robinson.) In both, the short tube is connected with a single hand-ball by means of a piece of rubber tubing, and one or two rapid and more or less forcible compressions of this hand-ball are sufficient to force a small quantity of the medicated powder into the nasal passages, either anteriorly or posteriorly, and to cover the surfaces of the parts with an even coating of it; the same result may be obtained by the use of the series of hard-rubber tubes devised by Robinson, which are so arranged that

Fig. 988.



Insufflator for anterior nares.

Fig. 989.

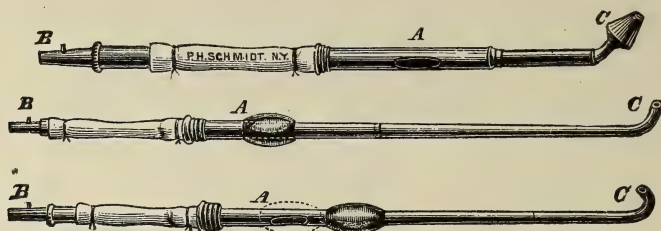


Insufflator for posterior nares.

they may be attached to the tube of the cylinder of compressed air, in the same manner that the spray-tubes are connected with it; or, in default of the latter, the tubes may be arranged with a piece of soft-rubber tubing and a mouth-piece, or even with a hand-ball, so that the powder may be either blown or forced through the nasal passages by the operator himself. Although various forms of *inhaler* and *steam-atomizer* play an important part in the popular treatment of nasal catarrh, they certainly, as a rule, exercise no evident beneficial effects, and can readily do harm. In cases of acute coryza, and in those of long-standing catarrhal inflammation, with a dry and irritable

mucous membrane, simple steam, or warm, atomized inhalations, may occasionally be indicated. Robinson recommends dry, cold inhalations of volatile

Fig. 990.



Robinson's tube for insufflation of nares.

matters in old catarrhal inflammations of the nasal fossæ, and says that excessive secretion is diminished by their use to a notable degree.

DISEASES OF THE NASAL PASSAGES.

ACUTE CORYZA.—Sudden exposure to a draft of cold, damp air, especially when the body is overheated, or the sudden chilling of any part of the cutaneous surface—especially of the extremities—under the same conditions, is all-efficient, even in healthy individuals, in bringing about an acute inflammation of the Schneiderian mucous membrane, which may remain in exceptional cases confined to one nasal passage, but usually affects both, and not infrequently extends thence into the neighboring cavities of the nose, and even involves the Eustachian tubes; other causes, in rarer instances, produce the same effects. Acute coryza is one of the earliest manifestations in several of the exanthematous fevers. Attacks of an obstinate character are produced by the inhalation of irritating gases and vapors, dusts, and powders; a peculiar idiosyncrasy often exists in respect to the irritation caused by certain drugs, such as ipecacuanha and iodine in some individuals. The internal use of iodide of potassium may cause an acute coryza, and the same is true of other mineral poisons. Trousseau has called attention to the relationship existing between asthma and coryza, and the latter is often the direct result of the extension of a catarrhal inflammation from contiguous mucous surfaces, such as the conjunctival, or that of the pharynx. As one of the initial manifestations of congenital syphilis, it is seen in the infant; and recently Mackenzie¹ has called attention to the influence of irritation of the sexual apparatus as an etiological factor in its production. Usually sporadic, it may become epidemic under special conditions of the atmosphere.

The question of its *contagiousness* has attracted some attention, and is still held in dispute.² Robinson believes that when encountered among the early conditions which point to the development of an acute, general disease of epidemic nature, it is so without doubt, just as the disease of which it forms an integral part; and that even when sporadic, and when not followed by ulterior symptoms, there is a probability of its being communicable. All practitioners will unquestionably recall instances in which the affection has developed successively, not simultaneously, in members of the same family, without other reason than the mere fact of its presence in some one person.

¹ Am. Jour. Med. Sciences, April, 1884.

² Blackwell, Med. Record, Jan. 10, 1880.

Fraenkel cites instances in support of the view of its direct contagious influence, while, on the other hand, various experimenters have failed in all attempts at inoculation of the healthy mucous membrane with the secretions of coryza. (Friedreich.) I believe it fair to assume, in the light of our present knowledge, and reasoning from analogy, that the secretions of an acute coryza are, at certain times and under certain conditions, contagious; and clinical experience endorses this view. These conditions depend mainly upon the peculiar susceptibility of the subject to its influence, and upon the stage of the nasal disease in which the secretions are taken, but in no event is the occurrence a common one; the affection, in the great majority of cases, runs its usual course in its subject without being communicated to others, and the question is of practical interest only in view of its possible bearing upon prophylactic measures.

The *symptoms* of an acute coryza are well known, and vary within considerable limits, from the mere consciousness of local uneasiness to severe pain, fever, and marked constitutional disturbance. The preliminary chill, or at least chilly sensation, is usually followed by a slight rise of temperature and increase of the pulse, with muscular pain and a general feeling of malaise. The local irritation and sensation of dryness in the nose are coincident with the stage of congestion and absence of secretion which mark the beginning of any acute inflammation of a mucous membrane, and lead to constant sneezing; this lasts but an hour or two, and is followed by an acrid, watery discharge from the nasal passages, which are now occluded by the swelling and engorgement of the tissues, so that oral respiration becomes a necessity, the senses of smell and taste are both blunted, and the voice becomes nasal in character. This occlusion is variable—the inter-vascular communications between the nasal passages being free and numerous through the peculiar erectile tissue, with large vein cavities, demonstrated by Kohlrusch and Bigelow to lie between the periosteum and the mucous membrane covering the turbinated bones, especially the inferior—and gravitation of blood and serum from one nasal passage to the other is often sudden and complete. The glandular structures being abnormally stimulated, the discharge increases progressively in quantity and changes in character, being at first mucous, with epithelial elements alone; and afterwards muco-purulent, with a few red blood corpuscles; or even purulent, and loaded with young cells. Meanwhile the inflammatory process extends, involving, perhaps, the frontal sinuses, when it gives rise to severe frontal headache; or the lachrymal duct, with resultant sensitiveness of the congested conjunctivæ to both pressure and light; or the Eustachian tubes, with pain in the ears, ringing noises, and dulness of hearing. If it extend to the pharynx, the patient will complain of sore throat, a usual complication; while if it involve the larynx and trachea, symptoms referable to those regions, with increase of the febrile movement, will be present.

The irritating qualities of the saline discharge, containing ammonia in the earlier stages, inflame and excoriate the margins of the nostrils and the upper lip; while the later discharge, muco-purulent, and greenish or yellowish in color, gives rise to an unpleasant odor, and not infrequently desiccates into crusts which are removed with difficulty. Fibrin is occasionally secreted, especially in infantile coryza, and in the form met with in exanthematous fevers, and forms a membranous layer over the turbinated bones, resembling, and requiring to be distinguished from, the pseudo-membrane of diphtheria (see page 787). The attack lasts from three days to one week or more, in severe cases, and fresh attacks sometimes supervene when the first undergo resolution. Alternation from one nasal passage to the other may occur; and

recurrence of the disease, with intervals of a few days, and for an indefinite period, is occasionally met with. As a rule, however, complete resolution occurs within the above-mentioned time, especially if measures have been taken to control the inflammatory process. The termination of the disease in suppuration is very rare, and fatal cases of coryza have been recorded only as occurring in aged persons or in infants, in both instances death being due either to obstructed respiration or to interference with nutrition.

Acute coryza in the infant assumes features that are not present in the same disease in the adult, and the immediate danger is correspondingly increased. This increased danger lies both in the obstruction to nasal respiration caused in the small and narrow passages by the tumefied mucous membrane, and in the difficulty with which the child is nourished, owing to its inability to hold its mouth, which is required for respiratory purposes, closed long enough to take the breast. If the attack be prolonged, not only will the infant lose strength, but the prognosis, in not a few instances, will become decidedly grave.

Syphilitic coryza in the infant is not always clearly defined as regards its true nature. An acute, persistent coryza, occurring in a very young infant, must always be regarded with suspicion; and, if a clear clinical history of the disease in the parents fail, resort to a mercurial course of treatment is certainly justifiable in attempting to establish the diagnosis.

Gonorrhœal coryza in the infant is the result of infection of the nasal passages by secretions from the vagina of the mother during delivery; and, when seen in the *adult*, arises from the direct conveyance of the poison to the nasal mucous membrane by the fingers, soiled pocket handkerchiefs, and the like. The symptoms are those of an aggravated, purulent, catarrhal inflammation or coryza.

Treatment of Acute Coryza.—The success of the abortive treatment of an acute coryza depends entirely upon the promptness with which it is instituted. Many remedies are vaunted—none, perhaps, are specific and unfailing in their action. Among the commonest is the administration of a full dose of the tincture of the chloride of iron, or quinine (gr. x–xv), followed at bedtime by hot alcoholic drinks, and a mustard foot-bath; or, if much local pain and distress exist, a Dover's powder (gr. x). Cohen advises the administration of chloroform to produce free anæsthesia, and claims that an attack may thus be aborted. Robinson recommends one of the following prescriptions:—

R.—Spirit. ammoniæ aromat., f℥iss.

Sig.—Teaspoonful in water (f℥j–f℥iss) every two hours.

Or,

R.—Ammonii carb., ℥j;

Liq. morph. sulphat. (U. S.), f℥j;

Mist amygdalæ, ad f℥iij. M.

Sig.—A teaspoonful in water (f℥j) every hour during six hours, and afterwards every hour and a half.

If there be much fever, tincture of aconite root ($\frac{1}{8}$ to $\frac{1}{4}$ of a drop to each dose) may be substituted for the morphine in the last mixture; and for the relief of the local inflammation and its attendant pain and discomfort, a powder of—

R.—Pulv. fol. belladonnæ, gr. xx;

Pulv. morph. sulph., gr. ij;

Pulv. acaciæ, ad ℥ss.

may be insufflated into the nasal passages both anteriorly and posteriorly.

The inhalation of simple hot steam, or of steam medicated with compound tincture of benzoin, is also often grateful to the patient; and a powder of sugar of milk, gum, or bismuth, rubbed up with a little morphine (gr. ij-3j), or one of starch powder with an equal part of camphor, is of service, if used as a snuff. After the discharge, however, has once set in—in other words, after the inflammatory process has once been firmly established—such measures fail as abortive means, and the efforts of the physician must be limited to curtailing the affection by controlling, as far as is possible, its inflammatory action. To this end the above remedies may be continued, aided and combined with such diuretic, diaphoretic, and laxative mixtures as are indicated in the special case.

The local use of inhalations of iodine, much vaunted creasote, carbolic acid, ammonia, and the like, in this stage of the affection, are of little if any service, aside from giving temporary relief, and are sometimes positively harmful.

External applications of emollients, such as vaseline or suet, occasionally give relief; and the same may be said of the use of vapor or hot-air baths.

As the process reaches its later, inflammatory stages, and the muco-purulent discharge sets in, local treatment may be employed with considerable success. It should consist in the application, by means of the spray apparatus, of some watery solution of an astringent (see page 770) to all parts of the inflamed and turgid mucous membrane, and this should be continued at suitable intervals until complete resolution has been established; for there can be no question that it is to neglect of these cases of acute coryza, especially in this stage, and to indifference to the fact of their complete or incomplete resolution, that the development of chronic catarrh can be charged in a majority of instances.

Acute coryza in the infant can best be treated by thorough cleanliness, attained by the employment of a camel's-hair pencil, used with a weak solution of borax to wash out the nasal passages, and by the subsequent insufflation of powders into the nasal passages anteriorly. Robinson recommends one of equal parts of finely pulverized white sugar and camphor with powdered tannin (gr. xl-3j), and speaks enthusiastically of its good effects. If it be determined that the syphilitic taint exist, to this local treatment must, of necessity, be added the use of some form of mercurial, or of mercury and iodide of potassium, in doses suited to the age of the child, and continued for days or weeks, according to the judgment of the practitioner and the demands of the particular case.

IDIOSYNCRATIC CORYZA—or, as it has been variously termed, rose or June cold, hay fever or asthma, and autumnal catarrh—may be defined as an acute coryza, showing a peculiar periodicity, and not unfrequently attended by reflex, asthmatic symptoms. It is due, as far as our present knowledge extends, to the inhalation, by persons possessing some peculiar and individual idiosyncrasy, of the pollen of certain grasses or flowers; and while it shows no distinction in attacking both dwellers in cities and dwellers in the country, it shows a predilection for those of high estate. (See page 843.)

Its treatment will not vary, in general, from that of an ordinary acute coryza; but it is often unsatisfactory and even futile, unless a temporary change of residence be made during the usual duration of the attack. With the object of destroying the vegetable organisms upon which the disease is supposed to depend, sprays or injections of carbolic and salicylic acid are used. Helmholtz advises the use of an injection of the hydrochlorate of quinia (1-100). A plan of treatment, however, which succeeds one year in aborting or

relieving the attack, will often fail the next. There is no specific remedy for the disease. The asthmatic complication may often be quickly relieved by the use of the following prescription:—

R.—Potassii iodidi, ʒj;
 Liq. potassii arsenitis, fʒj;
 Aquæ, fʒiv. M.

Sig.—A teaspoonful every four or six hours.

CHRONIC CORYZA.—The term chronic coryza, or chronic nasal catarrh, may very properly be used to replace a variety of terms which are to day employed in literature to signify one and the same affection. I believe that such a multiplicity of names falls far short of its object, can but serve to confuse the subject, and leads to faulty diagnosis and often to improper treatment. Bosworth, from a pathological point of view, if not correctly from an anatomical, defines the nasal cavities as extending from the nostrils to the free border of the soft palate, thus including the upper pharynx. Clinical experience teaches us that in most, if not in all cases of chronic nasal catarrh, the vault of the pharynx is involved in the morbid process; and the converse is likewise true: though the pharyngeal process be the more prominent, few cases exist in which the nasal passages also are not implicated. Chronic coryza, or chronic nasal catarrh, may therefore be defined as a chronic, catarrhal inflammation of the nasal mucous membrane and that of the vault of the pharynx, and the term should be understood to include those of post-nasal catarrh, post-pharyngeal catarrh, retro-nasal catarrh, and adenoid hypertrophy of the vault of the pharynx, which are so commonly used. Clinically, several varieties of chronic coryza are met with, each possessing individually appearances upon rhinoscopic inspection, giving rise to widely different symptoms, and requiring a distinct method of treatment. Upon the correct appreciation of the differences between these varieties, depends the success of the measures undertaken for their relief.

The varieties of the disease are classified by Bosworth¹ in a form, that, when slightly modified, commends itself for its simplicity and clearness, and can be proven to be clinically true. 1. *Simple chronic coryza*, a chronic inflammation of the nasal mucous membrane, characterized by an abundant discharge of mucus, but attended by no marked structural changes. 2. *Hypertrophic nasal catarrh*, a chronic inflammation of the mucous membrane, characterized by an excessive secretion of mucus or muco-pus, and also marked by certain structural changes in the membrane, by which this is thickened or hypertrophied. This hypertrophy involves not only the membrane lining the nasal cavity proper, but also the glands at the vault of the pharynx. 3. *Atrophic nasal catarrh*, a chronic inflammation of the nasal mucous membrane, in which the glandular structures are implicated to such an extent as to interfere seriously with their function, the membrane thus lacking its normal supply of mucus, and becoming dry, and secretions accumulating subsequently into dry, hard crusts, and decomposing, giving rise to a purulent fetid discharge and to an offensive odor (fetid catarrh).

Simple Chronic Coryza.—Seen as a rule, perhaps, as the evident and direct consequence of oft-repeated, and especially of neglected, attacks of acute inflammation, it, on the other hand, frequently manifests itself by a slow and gradual progression, without previous recognizable cause, and by no means necessarily dependent upon any constitutional taint of scrofula, although the possible influence of the latter, as well as of syphilis, herpetism, and, with adults, diathetic conditions, upon its causation, should not be overlooked.

¹ Bosworth, Diseases of the Throat and Nose. New York, 1881.

The main symptom is the increased discharge of mucus or muco-pus, which, being semi-fluid and thin, is easily removed by blowing the nose, or by being drawn back into the pharynx and thence expectorated. There is no thickening of the mucous membrane, and consequently no obstruction to nasal respiration and no change in the voice. The disease being confined, as a rule, to the respiratory portion of the nasal passage, the sense of smell suffers no interference, and, the membrane being soft and moist, there is no tendency to the accumulation of secretions into crusts, nor to decomposition. The main importance of the affection then, its symptomatology being but slight and giving rise to no annoyance, lies in its tendency to progress into the further and more serious forms of catarrh unless it be promptly arrested by judicious treatment. Rhinoscopic examination will show a reddened and congested mucous membrane flecked with mucus, throughout the nasal passages. At the vault of the pharynx the appearances are more marked, and the glandular structures here present are swollen and covered by a thicker and more tenacious mucus.

Aside from meeting any indications for constitutional remedies that may exist in a given case, the *treatment* lies—and the statement is true for the large majority of instances—solely in the local application of medicaments, in spray or powder, to the affected nasal passages. To insure the successful use of these, thorough preliminary cleansing of the passages is requisite. This may be accomplished, perhaps, by the patient using his handkerchief, unaided by any form of artificial apparatus. Should the latter, however, be found necessary to effect the complete removal of the secretions—and I repeat that an apparatus is much oftener used than is really needed (see page 758)—the coarse spray-producer, already described, may be employed with an alkaline, cleansing solution to the best advantage (see Fig. 981); rarely, if ever, in this form of the disease, is the posterior nasal syringe required. Following the cleansing process, which must be undertaken by physician or patient with at first daily, and then gradually diminishing, frequency, the next step consists in the application of the medicament, usually a mild alterative, resolvent, or astringent solution or powder. If the spray apparatus in one of its forms—preferably the spray with compressed air as the motive power—be chosen as the means, some one of the following solutions may be used with the anterior or the posterior nasal spray-tube, or both, and should be selected with due deliberation, in view of the special indications presented by the case, care being exercised that the application is of such a strength as to cause no irritation of the nasal mucous membrane, one much more susceptible than that of either pharynx or larynx. A preliminary, careful trial with the chosen solution or powder will quickly serve to prove the membrane's peculiar susceptibility, in a given case, to both the drug and its strength, and such a trial should be made in every instance. The following are the solutions that I most commonly use, given in the order of their preference: (1) *Zinci iodidi*, gr. x- $\bar{f}\bar{3}\bar{j}$; (2) *Zinci sulpho-carbolat.*, gr. $\bar{i}\bar{j}$ - $\bar{f}\bar{3}\bar{j}$; (3) *Zinci sulphat.*, gr. v- $\bar{f}\bar{3}\bar{j}$; (4) *Ferri et ammonii sulphat.*, gr. iv- $\bar{f}\bar{3}\bar{j}$; (5) *Ferri perchloridi*, gr. v- $\bar{f}\bar{3}\bar{j}$; (6) *Acidi tannici*, gr. v-xx- $\bar{f}\bar{3}\bar{j}$; (7) *Potassii chlorat.*, $\bar{\partial}\bar{j}$ - $\bar{f}\bar{3}\bar{j}$. In any one of these formulæ, "*Listerine*"¹ may be substituted, in part, for the water, in the proportion of one part of the former to three of the latter. If the simple rhinitis has advanced far towards the hypertrophic stage, then I commence at once with—

¹ This preparation contains the essential antiseptic constituent of thyme, eucalyptus, baptisia, gaultheria, and mentha arvensis, in combination; each fluidrachm also contains two grains of benzo-boracic acid. It may be used in any of these solutions, in part with water, as a menstruum, and will be found to serve a useful and pleasant purpose where an antiseptic is desirable.

R.—Iodini cryst., gr. iv ;
 Potassii iodidi, gr. x ;
 Zinci iodidi,
 Zinci sulpho-carbolat., āā ʒj ;
 "Listerine," ʒj ;
 Aquæ, ad fʒiv. M.¹

In case the solutions, mainly of mineral astringents, that have been given, are not well borne, a powder may be substituted with excellent results, and, indeed, is particularly applicable in this form of the disease. As a rule, however, I am not a warm advocate of the use of powders in the treatment of rhinitis. In the form under consideration, where the secretions are readily removable, and the parts soft and absorptive, they will do good, but in hypertrophic rhinitis they are, I believe, of little use, and in atrophic or fetid rhinitis, they are absolutely contra-indicated. The powders may be applied by means of the anterior or posterior nasal powder-blower, after the parts have been well cleansed.²

Whatever be the plan of treatment instituted—and it and its details may readily be determined upon from what has been said—it is to be steadily persevered in, not necessarily in these cases under the direct manipulations of the surgeon himself, but certainly under his general supervision, and at suitable intervals, until the morbid conditions for which it was undertaken are alleviated.

HYPERTROPHIC NASAL CATARRH.—If the simple form of chronic catarrh just described be permitted to run its course without interference, in certain cases the results of the continued chronic inflammatory process are sooner or later seen in marked proliferation of all the normal elements of the delicate mucous membrane—in other words, in a true hypertrophy of tissue. This hypertrophy, specially prone, mainly from anatomical reasons, to take place in the nasal passages, affects both the superficial and deep layers of the

¹ In order to save repetition, the formulæ of the solutions more commonly used in the treatment of the various forms of nasal catarrh, are here given in the usual strength in which they are employed. Other combinations and other remedies will suggest themselves.

Acidi tannici, gr. v—xx—fʒj.	Zinci chloridi, gr. iij—fʒj.
Aluminis, gr. v—fʒj.	Zinci iodidi, gr. x—fʒj.
Auri chloridi, gr. x—fʒj.	Zinci sulphatis, gr. v—fʒj.
Cupri sulphatis, gr. v—fʒj.	Zinci sulpho-carbolatis, gr. ij—fʒj.
Ferri et ammonii sulphat., gr. v—fʒj.	Argenti nitrat., gr. ij—iij—fʒj.
Ferri perchloridi gr. v—fʒj.	Ammonii chloridi, gr. v—x—fʒj.
Ferri sulphatis, gr. v—fʒj.	Tinct. krameriæ, fʒj—fʒj.
Potassii chloratis, ʒj—fʒj.	Tinct. kino, fʒj—fʒj.

² The following formulæ for powders are taken from Robinson and others :

R.—Acid. salicylic, gr. x ;	R.—Pulv. iodoform., ʒij ;
Acid. tannic.,	Pulv. camphoræ, ʒj ;
Bismuth. subcarb., āā ʒj. M.	Pulv. acid. tannici, gr. v ;
	Pulv. acaciæ, ʒij. M.
R.—Zinci chloridi, gr. v ;	R.—Hydrarg. chlor. mitis, ʒj ;
Pulv. belladonnæ, gr. x ;	Pulv. morph. sulph., gr. j ;
Pulv. amyli, ʒss. M.	Pulv. bismuth. subnit., ʒij ;
R.—Argenti nitrat., gr. ij ;	Pulv. sacch. alb., ʒij. M.
Bismuth. subnit., ʒij. M.	
R.—Pulv. cubebæ, ʒss ;	R.—Ferri et ammonii sulph., ʒj ;
Pulv. sodii bicarb., ʒij ;	Pulv. amyli, ʒj. M.
Pulv. acid. salicylici, gr. x ;	
Pulv. sacch. alb., ʒij. M.	R.—Aluminis, ʒj ;
	Pulv. amyli, ʒj. M.
R.—Ferri sulphat., ʒj ;	R.—Potass. chlorat., ʒss ;
Pulv. amyli, ʒj. M.	Pulv. amyli, ʒj. M.

mucous membrane, the changes consisting in the development of new connective-tissue elements and cellular infiltration in the deeper structures; implication of the muciparous glands, which become distended, and their walls thickened, especially those located at the vault of the pharynx where the hypertrophic process expends itself more upon the glandular elements than upon the mucous membrane proper; and increased cell-growth in the epithelial elements, leading rapidly to abnormal thickening of the superficial layers; the bloodvessels of the parts, at the same time, become dilated and increased in number, their hypertrophy occurring especially over the inferior turbinated bone, in the reticulated structure, or erectile stroma, which lies between the periosteum and the superjacent mucous membrane.

This hypertrophy, involving then all the structures which overlie, especially the two inferior turbinated bones, seldom presents a perfectly smooth surface. At the posterior extremities of the inferior turbinated bones, the nodulation and irregular thickening are most marked.

The *symptoms* of this affection are dependent upon the pathological changes which have been described. The hypertrophy of the tissues, especially throughout the respiratory channel of the nose, leads to intermittent or permanent occlusion and obstruction to the passage of the air current, while the involvement of the glandulæ, especially at the vault of the pharynx, gives rise to an excessive discharge of thick, tenacious mucus, or muco-pus, of a yellowish and opaque appearance. Upon this obstruction, caused by the hypertrophied condition of the parts, depends also the interference with the senses of smell and taste, and ultimately—from this cause, and also from the extension of the inflammatory process—with the sense of hearing, through involvement of the Eustachian tubes and perhaps of the middle ear; and likewise the change in the character of the voice, which acquires a nasal intonation. The increased flow of secretion, prevented from passing normally from the anterior nares, runs into the pharynx or lodges behind the velum, and is only removed thence by means of vigorous and disagreeable efforts at hawking and clearing the throat. (It may here be observed, that this sensation or symptom, one commonly complained of by the patient, needs to be differentiated as to its cause from the precisely similar one, to which the presence of an elongated uvula will give rise.) Contrary to what is generally believed, fetid or offensive secretions are not an accompaniment of this variety of catarrh, nor is the occurrence of crusts a common occurrence. Ulceration never occurs, and epistaxis only occasionally, and then from the anterior portions of the nasal septum, and as the result of direct, mechanical interference with the parts by the patient (see page 789). Partly by the gradual extension of the inflammation, from the nares and upper pharynx to the contiguous parts, and partly through the pernicious results of enforced oral respiration (see page 402), constantly aggravated also, I do not doubt, by the violent efforts at hawking made by the patient, the inflammatory process extends to the lower pharynx, and thence invades, in course of time, both the larynx and upper trachea. Symptoms referable to the chronic inflammation of these organs—mainly sore throat, cough, and alteration in the character of the voice—must then be added in time to those of the original condition. The mucous membrane of the whole upper respiratory tract, under these circumstances, becomes irritable, and peculiarly susceptible to the influence of cold and dampness.

Upon examination of the nose *anteriorly*, with the aid of a nasal speculum and good illumination, distinctive appearances can be easily recognized. The visible mucous membrane is red, thickened, velvety in appearance, and vascular. The anterior hypertrophied extremity of the inferior turbinated bone may project so far outwards into the nasal passage as to touch the septum,

opposite to it; its tissues are soft and doughy, and when indented by a probe recover themselves slowly. The hypertrophy seems to affect the tissues upon the inferior surface of the bone most decidedly, and the inferior meatus of the nose is often occluded by the mass; the middle meatus may be overhung by the thickened membrane coming from the middle turbinated bone, but to a less extent. The floor of the nostril is free, and usually the side of the septum. All parts are more or less decked, unless recently cleansed, with thick, tenacious mucus.

Posteriorly, by the aid of the rhinoscopic mirror, the posterior extremities of both middle and inferior turbinated bones, especially the latter, will be seen to present peculiar and characteristic appearances. The hypertrophy of the tissues is much more marked usually than is the case in the anterior nares, and the parts are covered by a thickened mucous membrane, of a whitish-gray color, and with an irregular, corrugated and fissured surface; the extremity of the inferior turbinated bone, indeed, resembles an irregular-shaped tumor, lying on the floor of the nostril, and its size may be so great as to nearly, perhaps completely, occlude the posterior orifice of the naris. The condition here described may exist in varying degrees in both nasal cavities, and the obstruction in the passages that it causes, is still further increased by the thickening of the tissues upon both sides of the nasal septum, especially in its upper portions.

The parts at the vault of the pharynx have been alluded to both in respect to their peculiar nature and structure, made up as they are mainly of glandular tissue, and in reference to the fact that they are always implicated, to a greater or less extent, in any case of chronic inflammation of the nasal passages, of some duration; it remains to be added that the physical results of a chronic inflammation of the "pharyngeal tonsil," as it is termed, are peculiar. The glandulæ are involved to a much greater extent than the mucous membrane, and as a result of their excessive hypertrophy, added to and increased by the hyperplasia of their connective tissue and the increase in number and size of the bloodvessels, associated with the thickening of the mucous and submucous structures, a veritable tumor or tumors are developed, which have received the specific name of *adenoid vegetations of the vault of the pharynx*, and are often treated of as a separate and distinct affection.¹ The size, configuration, and extent of these vegetations, or adenoid hypertrophies, are variable; they may exist only to such a degree as to cause a slight elevation of the tissues at the vault of the pharynx, and to obliterate its concavity; they may stud the entire pharyngeal roof, from side to side, hang over the posterior orifices of the nostrils, and completely hide the pharyngeal orifice of the Eustachian tube; the masses may be fimbriated, hang in grape-like clusters, or be cylindrical. I have seen them so large that the entire upper pharynx was occluded and occupied by the tumor, and that the lower edge of the mass was readily brought into view, through the mouth, by simply drawing the soft palate slightly forwards. Such excessive conditions, however, are unusual; generally, a rhinoscopic examination will show the rounded vault of the pharynx, and occasionally its upper lateral walls, to be occupied by a thickened and nodulated mass projecting strongly here and there from the underlying bony surface in the form of longitudinal ridges, and traversed in various directions by seams and fissures. As a rule they appear as flattish cushions, and only occasionally present themselves as small, isolated and rounded masses, or are gathered into "worm-like" clusters. The mass here described tapers off as it approaches the middle pharynx, until

¹ W. Meyer, Hospitals-Tidende, Nov. 4 og 11, 1868. Medico-Chirurgical Transactions. London, 1870. Löwenberg, Les Tumeurs adénoïdes du Pharynx Nasal. Paris, 1879.

finally a smooth, though congested mucous membrane, dotted with small rounded eminences, marking the site of the outlying hypertrophied follicles of the pharyngeal tonsil is reached; above, it is separated from the plane of the posterior nares by a sharp, deep line of demarcation. The consistency of the tumors is soft, they do not bleed readily, and their color is of either a light pink or deep bluish-red. They are, as a rule, seen only in children and young persons. Adults, even the victims of an old-standing nasal catarrh, seldom, if ever, exhibit the appearances of excessive hypertrophy of the glandular tissues at the vault of the pharynx, here described. Its absence in them, and its frequency in children, would seem to argue in favor of an atrophy of these structures, as life advances; or, as Cohen suggests, it may be that changes occurring towards middle life, render this tissue like the analogous tissue of the tonsils and agminated glands of the intestine, insusceptible to the catarrhal inflammations of youth.

Treatment.—Since hypertrophic nasal catarrh is the form of the affection which more frequently presents itself for treatment, mainly on account of the annoying symptoms to which it gives rise in the patient, the consideration of the medical and surgical measures adapted for the relief of its morbid conditions, assumes special importance. Fortunately, the surgeon is here in a position, mainly through the employment of surgical means¹ it must be admitted, to attain excellent and often brilliant results.

Aside from the occasional employment in these cases, as well as in the other forms of nasal catarrh, of a general remedial course of treatment suited to the existing diathesis, and the indications for the employment of which will suggest themselves in each individual case, the question here arises, whether any of the special agents of the Pharmacopœia, that have been from time to time recommended as having a useful therapeutic effect upon the mucous membrane of the respiratory passages in a diseased condition, is in reality of great value. I believe that this is questionable. I have made use of many, and have never been able to convince myself that any one possessed a decided, specific effect. Cubebs, ammoniacum, muriate of ammonium, and perhaps sulphur, have given the best temporary, and sometimes permanent results. In each case, however, their use has been associated with that of local and direct treatment of the mucous membrane. The latter is of unquestionable value. If the disease is moderate in extent, and the hypertrophy of the tissues not excessive, complete resolution may be effected by the application of such astringent and resolvent solutions, in spray, as are specially indicated. Preliminary instrumental cleansing of the nasal passages will probably be requisite in the majority of instances; but the practitioner, bearing in mind that this may be a possible source of irritation, should always assure himself first that the removal of the secretions cannot be effected by the patient's blowing his nose, etc. The nasal spray apparatus, with the cleansing solution (see page 758), here renders effective service when its use is necessary. Occasionally it must be superseded by the posterior nasal syringe, when the secretions, especially at the vault of the pharynx, are thick and tenacious, or when the occlusion of the nasal passages anteriorly is so great that a spray cannot be forced through them. Following the cleansing process comes the next procedure, viz., the application of medicated spray, suited both in strength, amount, and nature to the individual case (see page 769); or, if solutions of astringents or other drugs are not well tolerated, the insufflation of the proper powder.

On the other hand, if the catarrhal process be first seen in its advanced stages, when a firmly organized neoplastic tissue exists in large degree, and

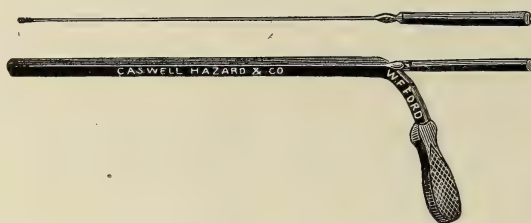
¹ Seiler, Surgical Treatment of Nasal Catarrh. Phila. Med. Times, No. 362. 1881.

seriously encroaches upon the nasal cavities, associated with a chronic inflammation involving the greater part of the naso-pharyngeal mucous membrane, the best that can be gained by the above plan of treatment will be the alleviation of some only of the more prominent symptoms, and more heroic measures will be required, chiefly the use of some means by which the hypertrophied membrane can be destroyed. Attempts to effect-absorption of the neoplastic tissue, through the introduction of hollow bougies into the nasal passages, where they are left for a time *in situ* (Hoppe), or the use of sponge tents, metallic bougies (Wagner), and the like, fail to give more than temporary relief, and the surgeon is obliged to turn to one of the following destructive agents, viz., the forceps, nitric acid, chromic acid, glacial acetic acid, nitrate of silver, the actual or galvano-cautery, or the *écraseur*.¹

Forceps, formerly commonly used in the nares for this purpose, have been justly supplanted by some one of the other means. The operation of tearing away portions of the hypertrophied tissue, over the turbinated bones, is harsh and attended by profuse hemorrhage.

Nitric acid has often served a good purpose in my hands. It is a powerful destructive agent, and with some care its action can be limited directly to the part to be treated. The guarded canula of Smith will perhaps here be of

Fig. 991.



Smith's guarded canula for applying nitric acid to the nasal passages.

service. A small probe, its end wrapped in absorbent cotton and saturated with the acid, is passed through a suitable nasal speculum into the naris to be operated upon, and drawn along, or firmly pressed upon, the turbinated bone at the point of its greatest convexity, contact being kept up for a few seconds; the pain quickly passes away, and on withdrawing the probe the parts are seen to have become well whitened or blanched; moderate inflammatory reaction, with a slough of varying depth, follows, while the consolidation of the submucous structures by the hyperplastic results of the inflammatory process and the contraction of the cicatricial tissue, occupying the site of the destroyed parts, serves to reduce the hypertrophy and its resultant nasal obstruction in a most satisfactory manner. Frequently, one application answers all purposes in freeing the nasal passage to the extent of allowing of uninterrupted respiration. The process, however, may require repetition. This little operation is one that I very frequently employ, and one in which I have much confidence. Owing to the danger of an excess of acid flowing over the healthy parts, and the difficulty of controlling this in a locality hard of access, this caustic is not adapted for use in the destruction of the adenoid hypertrophies met with at the vault of the pharynx. Its use should be limited to the parts reached through the anterior nares.

Chromic acid is less painful in its use than nitric acid, but possesses no other special advantage over it. It is well adapted for treating the glandular

¹ Gelatine bougies, moulded to a suitable form and medicated with various astringents, are advised by Guttman.

hypertrophies located in the pharyngeal vault, the small acicular crystals being easily taken up upon a suitably curved, cotton-covered probe, and carried behind the velum to the desired point.

Glacial acetic acid is highly recommended by Bosworth and others as an application to the hypertrophied tissues located in the nasal passages, on account of its well-known affinity for epithelial cells, and its action on the localized hypertrophies of the superficial layers of the integument. It is certainly efficient in destroying tissue, and easy of application by means of the probe; it causes no secondary inflammation, nor too much destruction, and it gives rise to no excessive pain. I have used it also in many instances with complete satisfaction, and I regard it as specially adapted for the more recent and more moderate cases of hypertrophy.

Nitrate of silver, formerly, and even to-day, extensively employed in this class of cases as a destructive agent, does not sustain its reputation. It causes but a superficial slough, and the application is of necessity frequently repeated in treating hypertrophied tissue of any extent. Moreover, owing to its powerfully stimulating qualities, it excites cell-proliferation and causes structural changes that are not desirable.

After the use of any form of caustic in the nasal passages, immediately upon the withdrawal of the probe, the parts should be flooded with an alkaline solution; the subsequent treatment of the case, at least until the slough has separated and the resultant ulcer healed, is based upon ordinary principles of cleanliness.

The actual cautery is seldom used, and possesses no special value to commend it.

The galvano-cautery offers a most radical and efficient means of destroying the hypertrophic and vascular obstructions of both nares and upper pharyngeal space, and is to-day widely employed for this purpose. Its action is rapid, but complete, and its use is not excessively painful. I believe, however, that we may accomplish, in very many cases, the same results by the use of less heroic measures. When the hypertrophies are extensive, Seiler justly observes, that the knife should be at a cherry red when the incision is made, when there will be neither hemorrhage nor much pain. If the heat be too great, bleeding will follow the incision, and if not hot enough, the pain will be severe. The immediate result of the incision or cauterization is the formation of an eschar, and acute inflammation surrounding the burned portion of tissue; the ultimate result, the formation of bands of cicatricial tissue which by their contraction bind down the tissues, and thus relieve the stenosed condition of the nasal passage for which the operation has been undertaken. The form of instrument to be employed to effect a given purpose, depends upon the choice of the operator and the special indications. Many varieties of electrode and apparatus exist. Voltolini uses an electrode with a single wire-loop point; Michel, a wire-loop *écraseur*; Thudichum, a wire loop; Browne, a bullet-shaped electrode; Shurley and Bosworth, a slender knife-electrode. Probably as convenient forms of electrode and handle as can be obtained for general use are shown in the accompanying figures (Figs. 992, 993). As will be seen, they are adapted for the treatment of both the nasal passages and the vault of the pharynx.

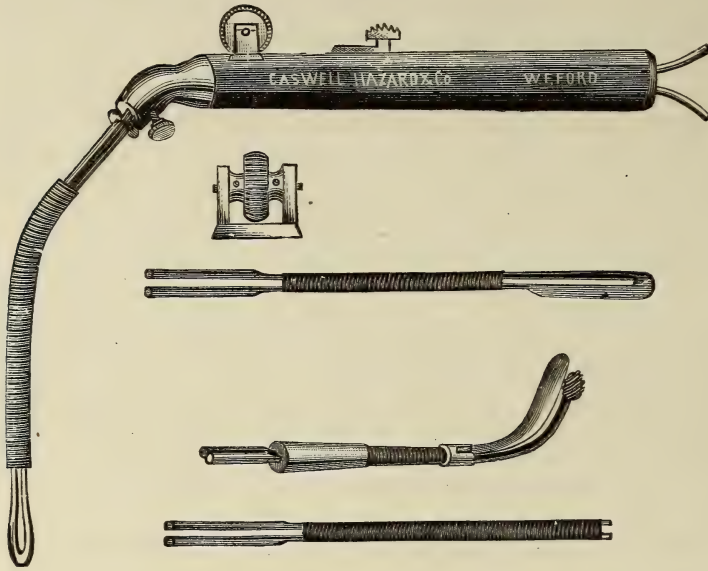
To protect the nasal passage during the introduction of an electrode into the anterior nares, the ingenious speculum of Shurley, with its movable ivory slide to cover the septum, will be found convenient.

During galvano-cautery operations upon the tissues at the vault of the pharynx, it may be necessary, especially in patients with irritable throats, to tie the soft palate forwards, in the manner described upon page 756.

In many instances, the hypertrophy of the tissues over the inferior turbi-

nated bone will be found to exist almost exclusively at its anterior extremity, and in such a case the procedure recommended by Jarvis will be found

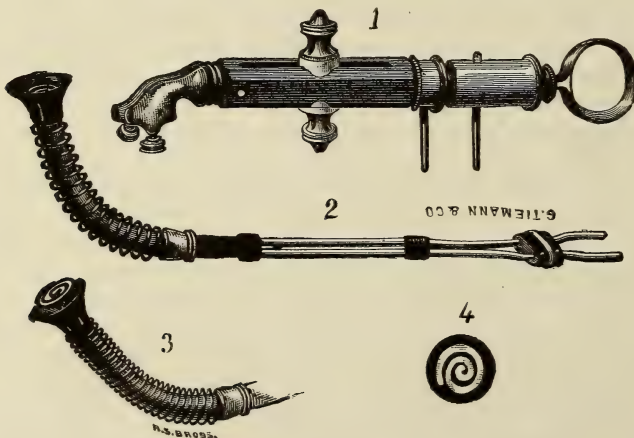
Fig. 992.



Nasal electrodes.

well adapted for its removal. The growths are usually sessile, but can be readily engaged in a loop of fine wire passed through the *écraseur* devised

Fig. 993.



Nasal electrodes.

by this surgeon (see Fig. 994), if their base be first transfixed with a slightly curved needle until the point projects above the growth into the nasal cavity; the loop is then arranged in such a manner that both the portion of the needle projecting from the nostril and the needle's point are encircled by it, very much after the manner of a hare-lip suture; the wire is thus prevented from slipping off, and the hypertrophy is readily secured, and is

removed by screwing down the milled nut of the instrument and drawing the wire home. The little operation is quick and almost painless, as well as bloodless. The relief that it affords is great.

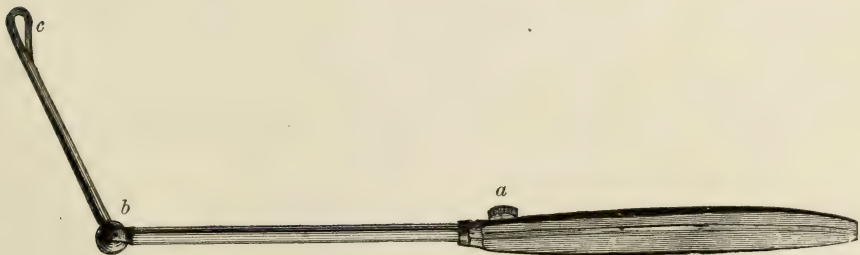
Excessive hypertrophy of the mucous membrane covering the posterior extremity of the inferior turbinated bone, and localized there, is no unusual condition, and may be of such an extent that the whole posterior naris is occluded by a rounded, sessile tumor of irregular surface, which grows downwards and backwards, until it rests partly upon the dorsum of the velum, and protrudes above into the upper pharyngeal space. It receives special mention here, because, owing to its peculiar position and shape, it cannot be safely reached and destroyed by any caustic method. The small wire *éraseur* of Jarvis here again certainly affords, when properly used, the most efficient and most satisfactory means of dealing with these localized hypertrophies, and of effecting their entire removal.¹

Fig. 994.

Jarvis's wire *éraseur*.

The instrument is light, and at the same time powerful; it can be passed through a narrowed nasal passage without difficulty, and, if the size and location of the hypertrophic tumor have been carefully studied previous to its introduction, and if the wire loop have been arranged accordingly, no great difficulty is experienced in ensnaring the growth. Slight traction on the instrument, and a few turns of the milled nut, will now secure it firmly, and the mass is then slowly cut through, to insure freedom from hemorrhage. The details of this little operation, which, if judged by its results, constitutes one of the more marked advances of recent rhinoscopic surgery, have been fully described by its originator in several recent articles.²

Fig. 995.



Nasal curette.

If the vault of the pharynx be involved in the disease, as is usually the case, especially in young subjects (adenoid vegetations or hypertrophies), active surgical treatment will be required, for sprays will be found ineffectual in producing any marked resorption of the hypertrophic masses. The choice

¹ Seller, Medical Record, October 29, 1881; Bosworth, Medical Record, July 9, 1881.

² Archives of Laryngology, vol. ii. No. 2 and vol. iii. No. 2; Transactions of the American Medical Association, 1881.

practically lies between the use of the galvano-cautery, the curette, caustics, and, finally, the forceps. Other means are advised, such as the use of the sharp spoon—a cutting edge fastened to a finger-guard—the Jarvis wire-snare, modified for use in the pharyngeal vault, and the like; but they do not possess the advantages of the first-named instruments and methods. The use of the curette is indicated when the hypertrophy of the tissues extends broadly in the shape of small nodulated masses over the entire pharyngeal vault. Caustics are only to be employed when the hypertrophy is of limited extent, and, as has been stated, chromic acid is preferred. Forceps, curved at a suitable angle to be passed behind the velum, and furnished with cutting blades, are extensively employed by foreign operators. I have of late used them exclusively in many operations, and have been well satisfied with the results.

ATROPHIC NASAL CATARRH.—As the result of the process of intra-nasal hypertrophy described in the last section—in certain cases following it, when it has lasted some time, or, more rarely, occurring early in the disease, before hypertrophy is far advanced—*atrophic*, or as it is sometimes termed, *fetid rhinitis*, is developed. It is much rarer than the preceding varieties. Its *etiology* is as follows. The deposition of newly developed connective and elastic tissue in the deeper layers of the nasal mucous membrane, in hypertrophic rhinitis, leads to two results: first, by its mere presence and amount, it may press upon, cause atrophy of, and destroy function in, the glands and follicles which thickly stud the mucous membrane; this may occur early in the disease, but when seen at a later period, as commonly is the case, the process of atrophy in the glands and other tissues has a different explanation. I believe it to be then due to the contraction which takes place in the elastic and connective tissue above alluded to. The more firmly this becomes organized in the course of time, the more firmly it compresses and consequently destroys the function of the secreting glands and follicles, mainly and primarily the serous glands, and with them the mucous membrane in which they lie, and the submucous structures undergo atrophy, and even more. If the process be long continued, the effect of this constant pressure, aided by the pressure exerted by the inspissated secretions and hard crusts, upon the turbinated bones, is to cause an interstitial absorption, an atrophy, in them; the result is shown, in the course of time, in the abnormally wide, roomy nasal passage, and in the almost rudimentary appearance of the turbinated bones, especially the inferior. From the process of atrophy here described, to the condition accompanied by fetor, or to the form of rhinitis termed fetid, is but a step: the latter condition follows the former closely—indeed is part of it, if it has lasted any time—and I see no need, clinically, to make a distinction between the two.

Fetor is the direct result of the atrophy, in this way: the secretions are scanty and tenacious, as has been said, and become more and more so as atrophy of successive follicles and glands takes place. (The explanation is simple: the atrophic process has affected, first and chiefly, the serous glands, which are numerous in the nasal mucous membrane; their function is, as is well known, by their secretion to render the nasal mucus thin and watery; but this function being abolished by their gradual destruction, the mucus secreted by the mucous glands, large numbers of which still remain intact, is viscid and tenacious.) This secretion adheres to the mucous surfaces, and rapidly desiccates in the respiratory current of air. Large crusts and scabs thus readily form, and cling closely, in the nasal passages and at the vault of the pharynx. Impacted in the narrowed parts of the canals, pent up beneath the turbinated bones, and constantly growing in size by the addition of the

secretions poured out beneath them and prevented from escaping, putrefactive changes set in, the matter thus imprisoned decomposes, and fetor is established. The irritation of the mucous membrane caused by the presence of these pent-up purulent discharges—for they rapidly change from muco-purulent to purulent—excites further discharge, and thus constantly aggravates the disease.¹

The *symptoms* are mainly if not wholly due to the presence of the large, inspissated crusts of mucus in the nasal passages, with their resultant obstruction to the respiratory current, and to their decomposition, which gives rise to the fetid and offensive odor which is the main characteristic of the disease. Quantities of inspissated muco-pus mixed with blood, together with more or less fluid secretion of a muco-purulent character, are discharged daily. Pain and irritability of the mucous membrane are also complained of. Attacks of epistaxis (due to the erosions of the membrane caused by the mechanical irritation produced by the hard crusts of mucus), are not infrequent. In the later stages, when atrophy has taken place, there is less obstruction, and the sense of smell is either more markedly interfered with or probably abolished. When the vault of the pharynx is involved, the accumulations of the hard secretions at this point, give rise to pain, discomfort, and the sensation of a foreign body being present. *Pharyngitis sicca* is usually associated with the latter condition, and symptoms referable to this locality are manifested.

Rhinoscopic examination will seldom fail to show appearances characteristic of the disease: in its early stages, a dry and glazed mucous membrane, and as it progresses, constant increase in the crust-accumulation and change in the character of the diminished secretion, until the stage of atrophy is reached, when the nasal passage will be seen to be wide and roomy. Curiously enough, the mucous membrane of both the nares and pharynx, when cleansed of its overlying, thick and discolored mucous accumulations, presents a fairly healthy appearance.

Treatment.—Beyond question, atrophic nasal catarrh is an intractable affection; that it not infrequently baffles all, even persistent, efforts for its cure, clinical experience shows. Much, however, may be done by regular and faithful treatment, to mitigate at least the most offensive of its characteristics, and ultimate cure need not be despaired of if the case be seen in its earlier stages.

The first and most important indication is the thorough, regular, and careful removal of all crusts and inspissated secretions from the nasal passages and vault of the pharynx. This process, I repeat, must be regularly and persistently repeated at suitable, probably daily, intervals. Instrumental aid, such as that of the forceps, probe, brush, and the like, may occasionally be required, especially in the later stages, to insure thoroughness. The nasal spray-apparatus, used with a cleansing and disinfectant solution (page 759), may serve the purpose of cleanliness when once it has been established by other means. When more powerful measures are required, the anterior or posterior nasal syringe must be employed. In the earlier stages, remedies are suitable which from their nature tend to restore the normal secreting power of the mucous membrane, through stimulation of its glandular apparatus, probably by their irritant effect. Certain of them may be applied in solution, by means of the compressed-air spray, and others in powder.

Bosworth recommends especially:—

R.—Pulv. sanguinariæ,
Pulv. myrrhæ, āā ʒj;
Lycopodii, ʒij. M.

R.—Pulv. galangæ,
Pulv. amyli, āā ʒj. M.

¹ See also the section on Ozæna.

Seiler¹ extols the use of a powder of nitrate of silver, or, in certain cases, a spray of an iron solution. Carbolic acid, salicylic acid, iodine, bromide of potassium, belladonna, and the like, are also employed.

In the later stages, after the cleansing process, the use of disinfectant solutions plays an important part, succeeded probably by the use of some powder containing pulverized iodoform. The treatment of so-called ozæna, as described in the next section, is also applicable here.

OZÆNA.—The affection which has just been described, atrophic, or as it is sometimes called in its later stages fetid, nasal catarrh, is precisely identical in its pathology, appearances, symptoms, and results, with the disease which is commonly termed *ozæna*. Of this I think there can be no doubt, certainly in the majority of cases. But it is possible, as claimed by Michel, that in exceptional instances the original seat of the disease may be in the accessory sinuses of the nose, and only ultimately lead to the changes described below. The term *ozæna*, however, as it is generally used—to indicate a disease, rather than describe a symptom, and to cover a class of nasal affections, varied in their causation, but all possessing one prominent symptom in common, viz., an intensely disagreeable smell or fetor, associated usually with a thick crust-formation in the nasal passage—leads to much misconception. Of these nasal diseases, syphilis, with its destructive inroads upon both the bones and cartilages of the organ, is the most common. But the same symptom is also present in other ulcerative affections of the parts, such as struma, lupus, and glanders, and it is even not wanting, in a lesser degree, in obstruction of the nasal passages from any cause, especially long retention of a foreign body, with resultant accumulation of the discharges and their decomposition. To class, however, all these affections under one name, on account of the similarity of one of their symptoms, is manifestly to vary widely from the truth, leads but to confusion, and detracts attention from their true nature, the correct appreciation of which is of importance both on diagnostic and therapeutic grounds. It seems to me preferable, therefore, to restrict the term *ozæna*—if it be deemed desirable to retain it—to those cases of ulcerative disease of the nose, such as syphilis, struma, lupus, etc., in which fetor is a prominent symptom, and is dependent upon necrosis of bone; and even then to use the term only with a qualifying adjective, as syphilitic *ozæna*, etc. The terms *catarrhus atrophicus ozænicans* and *rhinitis atrophica*, it may be mentioned, have both been suggested by foreign authorities to replace the name *ozæna* in the nomenclature of nasal diseases.

E. Fraenkel² informs us that, up to the present time, four reports of accurate post-mortem examinations in cases of rhinitis atrophica, or so-called *ozæna*, have been made, by Hartmann,³ Gottstein,⁴ Fraenkel, and Krause;⁵ these all found large nasal cavities, and slight development of all the turbinated bones, and they agree also in the results of their microscopic investigations, which showed connective-tissue change in the mucous membrane, with partial degeneration of the secreting elements. Zaufal builds his theory, as to the causation of the disease, on the existence of these large cavities (which he considers to be congenital), and believes all subsequent changes in the mucous membrane, and the fetor, to be consecutive to their enlargement and to the consequent accumulation of the products of secretion. In this view he is supported by Hartmann and Martin.⁶ Fraenkel differs from this view, and agrees with Gottstein and Schäffer in regarding

¹ Med. and Surg. Reporter, April 19, 1884.

² Virchow's Archiv, Bd. lxxxvii. 4 Feb. 1882.

³ Deutsch. med. Wochenschr., No. 13, 1878.

⁵ Virchow's Archiv, Bd. 85. 1881.

⁴ Breslau aerztl. Zeitschrift. 1879.

⁶ De l'Ozène vrai. Paris, 1881.

the size of the nasal cavities as the result of the last stage of a diffuse, at first hyperplastic, but subsequently atrophic, rhinitis (see page 778); and the results of two post-mortem examinations of his own agree with those of Gottstein and Krause. He does not, however, coincide with the latter¹ as to the similarity of the structural changes in ozæna with those of xerosis of the conjunctiva and callous stricture of the urethra, in both of which the odor of the secretion, if any, can be easily tested, and in neither of which has fetor been found as a symptom. His results lead him to believe that atrophy of the mucous membrane is necessary for the production of the fetor, and that the disappearance of Bowman's glands is an important factor. He adds that it is doubtful whether the atrophy always follows hypertrophy, or whether, as in the granular kidney, the process is not one in which there is at first no appreciable thickening of mucous membrane.

The majority of authors thus agreeing as to the pathology of the affection, two interesting points—(1) as to the immediate cause of the distinctive, fetid smell which has been alluded to, and the views of some authorities in regard to which have been given, and (2) whether or no the disease has a constitutional origin—claim attention. Upon these points opinions vary. Cozzolino² believes that simple ozæna may exist in certain individuals who have naturally fetid secretions, as of the feet and axillæ; Hebdemus, that the fetor is the result of a gaseous exhalation from a mucous membrane deprived of secretion; Krause finds a sufficient cause for it in the fatty degeneration of the newly formed cell-proliferations, even while they are in intimate connection with their original soil and before their appearance on the surface, and in the rapid change of the fat into fatty acids, and consequent decomposition, as proved by the appearance of margaric crystals in the crusts, these fatty acids being the invariable products of the decomposition of albuminous matters; Fournié holds that it is caused by the constitutional state of the individual—a state which excites a morbidly odorous secretion in the glands of the Schneiderian membrane; while Fraenkel's theory is, that the cause is to be found in suppuration of the mucous membrane, and E. Fraenkel's, that the presence of micrococci and bacteria is the chief factor in its development.

Is atrophic catarrh or ozæna always a constitutional disease? Fraenkel does not believe that its existence proves any special dyscrasia, but foremost in the list of constitutional predispositions to which it may be referred, he would place scrofulosis and perhaps syphilis. Cozzolino holds that it is a result of chronic rhinitis, and never occurs but in scrofulous subjects; this Krause doubts, saying that there is no ground for assuming that the constitutional idiosyncrasy, or the constitutional predisposition in the individual, upon which the disease depends, has any connection with scrofula. The theory of a constitutional predisposition is also held by Fournié.

The appearances of the disease, as they are seen in the nasal passages, are similar, though exaggerated in degree, to those described as being incident to atrophic catarrh.

Treatment.—The treatment of the affection will not vary, in the main, from that recommended for atrophic catarrh. The essential point is to insure thorough cleansing of the parts and their subsequent disinfection (see pp. 779, 780). The agents employed to neutralize the fetor are numerous, including antiseptics from permanganate of potassium down to iodoform. Fournié recommends boracic acid or salicylate of sodium. The cotton-wool tampon is generally well spoken of. Zaufal uses it to remedy the enlargement of the nasal cavities; Gottstein employs it to stimulate secretion. Fournié believes that when the cotton-wool is introduced into the nostril, it acts in a Listerian manner,

¹ Loc. cit.

² Rev. Mens. de Laryngol., 1 Nov. 1881.

that is, it prevents the germs from the external air from penetrating into and acting on the mucus, already too prone to decompose; and Fraenkel advises astringents and the galvano-cautery as the most serviceable means against the atrophy.

The whole matter of treatment is summed up tersely by Kendal Franks,¹ to the effect that, if the theory that the disease is due to atrophy of the mucous membrane is correct, there can be as little question of curing the affection as there would be of causing the retrogression of a granular kidney, or of a cirrhotic liver. By the application of strong astringents to the already atrophied mucous membrane, nothing is to be gained, though if we were able to get the disease in its hypertrophic stage, theoretically we ought to be able to effect a return almost to the normal condition.

Rouge² holds the view that it is impossible to have an ozæna without some lesion of the skeleton of the nasal cavities—a view in which, as has been said, I do not coincide, although I agree with the majority of the conclusions upon which he bases it, and hold that they serve equally well to corroborate the opinion above expressed as to the true cause of the disease; he advises that the upper lip and nostrils should be lifted together by first freeing them by incisions through the mucous membrane of the mouth, and dividing the cartilages at their attachment to the upper jaws. The anterior bony nares are thus completely exposed, and a good view obtained of the interior of the nasal fossæ, together with ample space for the introduction of instruments and the removal of diseased bone.

SYPHILITIC AFFECTIONS OF THE NASAL PASSAGES.³—Syphilis may exhibit various manifestations in the nasal passages.

In the infant, the disease appears *congenitally*, under the form of an acute coryza, with its attendant symptoms of swelling of the mucous membrane, obstruction to nasal respiration, profuse discharge, and hoarse voice, together with other evidences of the disease, such as affections of the skin, excoriations of the anus, etc. The evil effects of the nasal obstruction, as shown in the ineffectual attempts of the child to nurse, and its consequent inanition, have been elsewhere detailed (see page 766). The condition often becomes one of grave import. In addition to the ordinary constitutional treatment of the primary disease, it becomes requisite, in such cases, to thoroughly clear the nasal passages of all accumulated discharges, by the careful use of a syringe, with a solution of borax, chlorate of potassium, or the like, in warm water. Soothing ointments may then be applied with a brush, with good effect. The disease usually yields to this plan, without recourse being necessary to more heroic measures or to more active medication.

Chancre of the nostril is occasionally met with; Watson,⁴ Cutter, and others report instances of its occurrence.

The *secondary stages* of the acquired malady are occasionally characterized by an acute and persistent coryza, and, still more rarely, by superficial ulcerations of the mucous membrane. Mucous patches may appear about the orifices of the nostrils. The earlier symptoms of the disease are simply those of an uncomplicated nasal catarrh, from which it presents no points of diagnostic difference, and recourse, in attempting to establish its true nature, must always be had to the clinical history of the case. The ulcerations, slight as they are, are more characteristic; their progress is slow, and they

¹ Dublin Jour. Med. Sci., April, 1882.

² Nouvelle Méthode Chirurgicale pour le Traitement Chirurgical de l'Ozène. Lausanne, 1873.

³ See Schuster and Sanger, Vierteljahrsschr. für Derm. und Syph., Jahrg. iv. Heft i.-ii. 1877; and Mauriac on Naso-Pharyngeal Syphilis. Paris, 1880.

⁴ Med. Times and Gaz., April 16, 1881.

are usually found upon the cartilaginous septum. Rarely do they extend to any extensive destruction of tissue or of neighboring parts, and never, if controlled by judicious treatment.

The most destructive, the most common, and the most characteristic of the syphilitic affections of the nose, occur during the *tertiary period* of the disease—that is, at a date from five to fifteen years after the primary infection—and, as is the rule with the severer lesions of syphilis, are more apt to appear in broken-down, neglected, and strumous individuals. The ulceration, commencing in a gummatous periostitis, or in a localized gummy infiltration of the mucous membrane, rapidly becomes wide-spread and destructive, invading and destroying both cartilaginous and osseous structures, and eventuating in necrosis and discharge; permanent deformity, from sinking in of the nose, follows, from loss of its bony and cartilaginous supports. No part of the interior, or, in certain rare cases, the exterior of the organ, is sacred from the inroads of the disease. Vomer, perpendicular plate of ethmoid, cartilaginous septum, turbinated bones, the floor and walls of the nose, yield in turn. Crusts and necrotic bits of bone accumulate in the passages; a most intolerable fetor is developed; the discharge is stinking, bloody, and purulent; abscesses form, and may rupture externally, and the hard palate finally becomes perforated. In rare instances, serious consequences may still further follow from the extension of the destructive process to the interior of the cranial cavity, or from some incidental or accidental complication—lodgment of necrosed pieces of bone in the air passage or œsophagus.

The *diagnosis* of syphilitic disease of the nose is ordinarily not difficult; the clinical history of the case, the presence of the syphilitic cachexia, the appearance of the nasal ulcerations, and especially the detection with the probe of necrosed bone within the passages, together with the offensive odor and discharge, and the existence of ulcers in the pharynx and fauces, rarely leave room for doubt. Lupus, scrofula, tuberculosis, cancer, and the ulcers of the exanthemata, the only other main affections of the nose giving rise to ulceration (see page 784), are readily eliminated, in the absence of their characteristic appearances and constitutional symptoms. Special care must be taken not to confound cases of syphilis, attended, as they are, by an ozænic smell, with cases of simple ozæna, such as have been elsewhere described. The mistake is no unusual one, and the direful results of want of proper treatment, or the effects of mismanagement, in such instances, are well known.

Treatment.—The importance of prompt, efficient, and skilful treatment, both local and general, cannot be overestimated; the latter is always essential in controlling the disease; the former, of the utmost value in limiting its destructive course and hastening its cure. Iodide of potassium in full doses (gr. x, xx, to xxx, or more, three or four times daily), conjoined, if the necessary indications exist, with the administration of the preparations of iron, cod-liver oil, and the like, constitutes the sheet anchor of treatment, and its use is often attended with the most brilliant results. Mercury, I believe from experience, to be of less value in controlling the ulcerative action in this stage. The combined treatment may be preferred by some. Locally, the indications are to correct the offensive odor, check hypersecretion, and remove all the necrosed bone, which acts as a constant irritant. The first step is the thorough cleansing of the parts by means of a disinfectant solution (permanganate of potassium, liq. sodæ chlorinat., carbolic or salicylic acid, borax, creasote, etc.), used with the nasal douche, or, still better, some form of nasal syringe. The nasal spray-apparatus is rarely forcible enough in the stream that it throws to dislodge the thick and impacted accumulation of crusts, or to loosen necrosed bits of bone; indeed, both often require direct extraction at the hands of the surgeon, aided by forceps and

probe. This cleansing process thoroughly accomplished, the state of cleanliness thus obtained must be maintained by the repetition of the syringing, by either surgeon or patient, as often as may be necessary—certainly, at the outset, each day. After each cleansing, powdered iodoform may be insufflated into both nostrils, and over all ulcerated surfaces, by means of Smith's insufflating tube or nasal powder-blower. Some prefer the immediate inhalation of the vapor of iodine, or the insufflation of Trousseau's mercurial powder. The first plan I believe to be the best. The importance of removing as soon as practicable all necrosed bone will be apparent. It acts as a foreign body, keeps up ulceration, and prevents reparative action. Its extraction by means, usually, of the polypus forceps, is a simple matter, and is governed by ordinary surgical rules. Goodwillie has reported good results in his treatment of such cases by grinding or cutting away all dead bone with the burr of the dental engine, introduced through the nasal opening, and smoothing away all ragged and irregular surfaces that are left. The healing process and the duration of the disease are unquestionably considerably shortened by such a procedure.

ULCERATIVE DISEASES OF THE MUCOUS MEMBRANE OF THE NOSE.—Aside from syphilis, which, as has been shown, may in its progress destroy not only the mucous membrane, but the cartilaginous and bony parts of the nose as well, and give rise to all the symptoms of a marked ozæna, other ulcerative diseases of the nasal mucous membrane exist, the commoner ones comparatively unimportant, the more serious fortunately rare. Both classes still remain to be considered. *Catarrhal ulcerations*, as they have been termed, but which are in reality never more than slight erosions, are not the rule in uncomplicated nasal catarrh, and are but rarely met with. Contrary to general assertion, the *eczematous* form of nasal ulcer, if it may be so termed, is not uncommon in children, and may be associated with eczema of the upper lip and cheeks. The crusts frequently form so thickly about the nasal opening, that it is occluded by them as well as by the attendant swelling of the mucous membrane, and much nasal obstruction to breathing and discomfort are thus caused. A deep, painful *fissure* at the lower part of the nasal meatus is furthermore no unusual result, if the condition be neglected. In either case, a constitutional course of treatment suited to the indications, and locally, complete cleanliness obtained by the daily injection of an alkaline solution, and the prevention of the re-accumulation of the crusts by the use of some unirritating ointment, such as that of the benzoated oxide of zinc, glycerine of borax, etc., will quickly relieve the affection. It is as a rule not associated with an ozænic smell, unless there be considerable and prolonged obstruction to the exit of the nasal secretions. *Traumatic* ulcers, the result of the mechanical irritation caused by the lodgment or pressure of foreign bodies within the nasal passages, quickly heal when the offending substance is once removed. Ulceration of the nasal mucous membrane occurs among workmen in arsenic (paper-hangings), and in those who are exposed to the fumes of chromic acid. A more serious form of ulceration, extending even to the destruction of the cartilages and bones, occasionally occurs among the *sequelæ of certain fevers*—measles, scarlatina, smallpox, and typhus—perhaps also in erysipelas and chronic pyæmia. The local symptoms are marked and leave no room for question as to the diagnosis. *Scorbutic ulcers* of the nose may occur. Buzzard¹ says that in confirmed scurvy, the slightest pressure suffices to open the skin and to give rise to an ulcer, whose edges are hard, thick, and shining, and the surface fungoid and bleeding, and that the lips and nostrils are

¹ Reynolds's System of Medicine, vol. i. p. 744.

occasionally the seat of this form of ulceration. An intolerably offensive odor is emitted, and the exhaustion attendant upon it is often fatal. Watson has called attention to the fact that in paresis of the fifth pair of nerves, ulceration of the mucous membrane of the nose may occur as the result of the disturbance of nutrition, associated with their sensory function (*neuro-paralytic ulcers*). He adds that little can be done in the way of local treatment.

Scrofulous ulcers, according to Fraenkel, frequently occur in the victims of scrofula, upon the nasal mucous membrane. At times, and as a rule, small, at other times they may penetrate deeply, and destroy both bones and cartilage. Special care is necessary, in order to differentiate them from similar ulcers of a syphilitic nature.

GLANDERS.—The source of glanders in the human subject can almost uniformly be traced to an accidental inoculation of the virus from an animal affected with the disease, for isolated instances only exist where it has been communicated from man to man. The mucous membranes, and first that of the nasal cavity, early manifest symptoms of inflammatory and ulcerative action. At the outset, and following the general lassitude, pain in the back and limbs, headache, and rigors, the discharge from the nose is of thin, viscid, and light-colored mucus only. Gradually, however, there appears in the acute form of the disease, swelling and redness of the organ and its adjacent parts, accompanied by severe pain; its upper portion is especially sensitive to the touch, exhibiting a diffuse, erysipelatous swelling. The nasal discharge now becomes of a thicker consistence, more purulent, of a brownish-yellow color, sanguineous and offensive. Distinct tubercles are frequently seen, situated especially upon the alæ, and the formation of pustules and ulcers in the mucous membrane of the nose may be distinguished in many instances in the more malignant forms. These terminate in involvement of the perichondrium and perforation of the septum.¹ The constitutional disturbances attendant upon these local manifestations are marked. Aside from those already mentioned, the pulse and temperature are high, and the respiration embarrassed; delirium occurs early; swellings of a red color upon the legs, and pustules about the face, follow, the original pustules assuming a purplish tint. Diarrhœa and profuse sweating, with restlessness and increased delirium, are but the forerunners of the end, exhaustion and death closing the scene.²

In chronic glanders, the nasal lesions do not differ essentially from those in the acute form of the disease just described. They run a longer course, however, and are sometimes entirely absent.

The treatment resolves itself, practically, into that of the general condition. Little can be done locally, aside from the injection of disinfectant solutions into the nasal cavities for the purposes of cleanliness. Applications of tincture of iodine or nitrate of silver have been advised by Bollinger.

LUPUS.—If lupus of the cutaneous surface, especially of the face, be not present, the diagnosis of lupoid ulcers within the nose is a matter of some difficulty, since they are readily confounded with like affections of syphilitic origin.³ The points in differential diagnosis have been well stated by Durham. Attention must be directed to the history of the case, to the age of the patient, to the absence of other symptoms of syphilis, and especially of the characteristic cachexia which almost always accompanies the more serious syphilitic affections of the nose, and also to the comparative slowness with

¹ Consult the excellent article by Bollinger, Ziemssen's Cyclopædia, vol. iii. p. 356.

² See Schilling, Medico-Chirurgical Transactions, 1830-31.

³ See Moinée, Thèse de Paris, No. 236. 1877.

which the malady has progressed, and to the lateness of the period at which the bones have become affected.

If the little tubercular infiltrations of lupus can be recognized, and the tubercles present a compact, granular appearance, the diagnosis is confirmed; and it is further strengthened if the disease progress slowly, and if there be a manifest disposition towards healing, here and there, even while the ulceration is extending; anti-syphilitic treatment may be employed as a means of assistance in the diagnosis. If an anterior rhinoscopic examination be made, small, reddish-looking tubercles can usually be seen early in the disease to stud the mucous membrane; these soon break down in ulceration, the ulcers preserving to some extent their tubercular character, and the apices of the tubercles being concealed by hard crusts. As the ulceration progresses, the cartilages become affected, the septum is perforated, one or both alæ are destroyed, and the nasal bones are implicated. Serious deformity may thus be caused.

The *treatment* of lupus has elsewhere been considered;¹ it may be here added, however, that when possible to do so, the lupus-tubercles in the nasal mucous membrane may be destroyed by means of a fine galvano-cautery point, or even the actual cautery. Chromic acid, caustic potassa, and chloride of zinc, have been recommended for the same purpose, but their action is more difficult to control. Ure advises the use, as a destructive agent, of a thick layer of a paste composed of chloride of zinc with two or three parts of gypsum, and a little alcohol. Following the destruction of the tubercular masses, the resulting ulcers and the inflammation may be treated upon the principles already laid down elsewhere in this article.

TUBERCULOSIS OF THE NASAL MUCOUS MEMBRANE is regarded as a rare affection, and certainly is one to which attention has only been directed within very recent years. The number of cases as yet upon record is too small to furnish a basis for definite conclusions, or to clinically illustrate distinctive, diagnostic appearances in the ulcerations. The descriptions thus far given of the latter vary greatly, and although in many of the reported instances a careful microscopic examination has established beyond doubt their true pathological nature, in others this is open to grave suspicion. Following irregular and scattered granulations in the mucous membrane of the nose, ulcers are developed which are small, sometimes disseminated, but at other times confluent. They are superficial, with slightly thickened edges, and an irregular, unhealthy-looking base; they may occur at any point in the mucous membrane of the nasal passages, but are found especially over that of the septum, and are only observed in patients in whom physical examination will show pulmonary tuberculosis, probably in an advanced stage; even in such instances, their differentiation from the ulcerations of lupus, and occasionally of syphilis, becomes a matter of nice diagnosis.

The accessory cavities of the nose, the frontal sinus, antrum of Highmore, and ethmoidal cells, were never found to be tuberculous by Weichselbaum, in a careful post-mortem examination of some 164 tubercular subjects.²

¹ See Vol. III., p. 88.

² Fraenkel (Ziemssen's Cyclopædia, vol. iv.) quotes Willigk's statistics. In the post-mortem examination of 476 tubercular patients, tuberculosis of the nasal septum was seen but once. Laveran (L'Union Médicale, 1877, Nos. 35 et 36) gives two cases of tuberculosis of the nose. Riedel (Deutsch. Zeitschrift für Chir., Bd. x. 1878) gives cases of tuberculosis of the nasal septum. See also Thornwaldt, Deutsch. Archiv für klin. Med., Bd. xxvii. S. 586; Weichselbaum, Allg. Wiener med. Zeitung, Nos. 27, 28, 1881. (The microscopic examination in two cases fully reported is here given.) Fraenkel, Centralblatt für med. Wissensch., No 27, 1881 (Statistics).

NASAL DIPHTHERIA.—It is still an open question whether diphtheria of the nasal mucous membrane is ever a primary disease. Schuller¹ believes that it may be, but the case offered in support of his views is at best but a doubtful one; Kohts² asserts that it sometimes is, and that its local manifestations may either remain limited to the nasal passages, or, originating there, may spread thence into the upper pharynx, pharynx, and larynx. The converse is, beyond question, the commoner occurrence, and the local membranous evidences of the affection must extend from below upwards, by a process of gradual progression, before they are found within the nasal passages. Aside from the constitutional treatment of the disease, no local measures are usually employed in the case of nasal involvement, aside from injections or sprays of alkaline and disinfectant solutions. The relief that these give to the obstruction in nasal respiration, caused by accumulated secretion and membrane, and the consequent comfort of the patient, certainly indicate their use in all cases, aside from any direct influence that they may have upon the progress of the disease.

Pseudo-membranes in the Nasal Passages.—I have on several occasions been called upon to remove tough membranous exudations from the nasal passages, where they were giving rise to more or less obstruction of the air current, and to the symptoms of a chronic coryza. These cases have occurred in young patients, usually small children, free beyond all question from diphtheritic taint. The affection is purely a local one, and the membranoid mass is the result of a collection of tough, inspissated mucus, holding entangled epithelial débris. The masses are usually moulded about and over the inferior turbinated bones, to which they cling tightly, and the special point of interest in these cases lies in their differentiation from the somewhat similar-looking productions of diphtheria in the same locality. The absence of all constitutional disturbance, and of all local, acute inflammatory appearances in either nose or throat, readily serves to stamp their true character.

SUBMUCOUS INFLAMMATION AND ABSCESS OF THE NASAL CAVITY.—True phlegmonous inflammation of the nose can hardly exist, owing to the peculiar anatomical arrangement of its structures. Fraenkel has, however, called attention to a form of acute inflammation which, it is true, occurs but rarely, but which resembles a phlegmonous inflammation closely in its character, involves the deeper structures and periosteum, and gives rise to all the results of phlegmon. It is seen especially after direct injuries to the nose, but may arise without known or appreciable cause. Its locality may vary. Usually one nasal passage alone is affected, and this at some point other than the septum. As soon as an abscess forms it should be opened.³

Pustules of acne and small furuncles are not infrequently developed just within the openings of the nostrils, and lead to the formation of small, circumscribed abscesses, attended with much pain and the local evidences of acute inflammation. An inflamed hair-bulb is a common starting-point for the development of furuncle. Once incised with a small tenotomy-knife, these abscesses quickly disappear.

CASES OF PROFUSE WATERY DISCHARGE from one or both nostrils, without appreciable local cause, are reported by Paget,⁴ Althaus,⁵ Lingard,⁶ Tillaux,⁷ and Spiers;⁸ and others, in which the same condition was probably dependent

¹ Archiv für Kinderheilk. N. F. Bd. iv. Jahrg. 1871, S. 331.

² Gerhardt, Handbuch der Kinderkrankheiten, Bd. iii. 2te Hälfte, S. 18.

³ See also under Abscess of the Nasal Septum.

⁴ Lancet, vol. ii. p. 773. 1878.

⁵ Brit. Med. Journal, Dec. 7, 1878.

⁶ Ibid., Dec. 21, 1878.

⁷ Traité d'Anatomie Topographique, p. 56. Paris, 1877.

⁸ Lancet, March 5, 1881.

upon catarrhal inflammation of the nose or its accessory cavities, by Carter,¹ Spencer Watson, and Hewan.² The discharged fluid is clear and colorless, free from smell and taste, of a specific gravity of 1004, and of alkaline reaction; it contains proteid matter, probably albumen, chloride of sodium, phosphates, and a slight trace of iron, but no grape-sugar. Its quantity varies, large amounts often flowing away during the day, either at intervals, continuously, drop by drop, or sometimes so quickly as to form a stream; it is increased by exertion or straining, or by holding the head forwards, and its duration has been, in the reported instances, from nine to eighteen months. In none of the cases has there been any evidence of general ill-health, or evidence of local disease of the nose. In two, there was the history of a blow upon the skull, preceding for some time the appearance of the flow. The cause and the source of this large flow of fluid are involved in some obscurity. Paget expressed the opinion that it might be derived from either a frontal or an ethmoidal sinus, from the sub-arachnoid space, or from the sac of the arachnoid membrane; although a subsequent autopsy in the case which he reported showed its source to be the antrum. Lingard believed that in his case some fracture of the cribriform plate of the ethmoid might possibly have taken place, and have allowed the escape of cerebro-spinal fluid; a suggestion which also would cover the case of Tillaux. Althaus, on the contrary, asserts that these cases may be explained by the withdrawal of nervous force from the sphere of the trifacial nerve. The nasal mucous membrane receives its nervous supply chiefly from the ophthalmic branch of the trifacial nerve, and from the sphenopalatine ganglion, the secretion from the mucous membrane being caused by the sympathetic, and regulated and inhibited by the fibres of the fifth nerve. Remove, he says, this inhibitory influence of the trifacial, so as to allow the sympathetic fibres to rule supreme, and hypersecretion of liquid is the result. Injury or inflammation of the nasal twig of the ophthalmic branch of the fifth nerve may then be regarded as a cause, if not the cause, in the examples of the affection thus far recorded; and this view, in regard to any case, would be still further established if there should be anæsthesia of the mucous membrane of the nose, or of some portion of it, on the side corresponding to the flow.

The *treatment* that has been adopted in the few instances that are reported, consisting mainly of astringents locally, does not appear to have been attended with any marked success. If the theory of Althaus be correct, the use of the constant voltaic current is indicated, to restore the function of the trifacial nerve and thus check the excessive secretion. In one instance this has succeeded.

EPISTAXIS.

Hemorrhage from the nose, in which more than a moderate amount of blood is lost, is a very infrequent occurrence; that it may, however, give rise to serious danger, and even destroy life, is shown by the experience of many writers. Rhodius³ relates an instance in which eighteen pounds of blood were lost within twenty-one and a half days; Martineau⁴ one in which twelve pounds flowed away in sixty hours; and even seventy-five pounds have been known to be lost within a period of ten days.⁵ Gross⁶ has seen five fatal cases, in which death was caused either by imperfect plugging of the

¹ Lancet, Nov. 30, 1878.

² Ibid.

³ Obs. Med. Francof., 1576. (Obs. xc.)

⁴ Morgagni, De sed. et caus. morb., lib. i. epist. xiv. 23.

⁵ Act. Erudit. p. 205. Lipsiæ, 1688.

⁶ Syst. of Surgery, sixth ed., vol. ii. page 283.

nostrils, or because the operation was not performed until the patient was exhausted by hemorrhage. Edwards reports likewise a fatal case of bleeding from the nose,¹ and Parker Smith² lost twelve out of nearly thirty cases of diphtheria, in which, on account of the age of the patient, it was impossible to tampon the posterior nares. Epistaxis, which it should be borne in mind is but a symptom, may be either *primary*, in other words, dependent upon some intra-nasal lesion, or *secondary*, the sequel of some general constitutional condition or diathesis.

PRIMARY EPISTAXIS.—The common variety usually occurs from one nostril only, and is dependent upon direct violence or irritation. Blows, ulceration of the mucous membrane, and the presence of growths, especially when of a malignant character,³ constitute efficient causes. Cloquet⁴ mentions irritant gases and powders as giving rise to epistaxis, and finally idiosyncrasy, as shown in the peculiar results developed by the inhalation of certain odors, must not be forgotten. A very common, but not generally appreciated cause, lies in the existence of a small, seldom extensive erosion of the mucous membrane of the cartilaginous septum, just above the point of the former's junction with the skin. The term ulcer cannot be correctly applied to this lesion—certainly not in its earlier stages, and as commonly seen—for although there is of necessity some loss of substance, no marked excavation exists except in extreme cases. Catarrhal conditions may or may not coexist; they probably will, but it must be borne in mind that neither erosion nor ulceration is a feature of simple nasal catarrh. On the contrary, I believe that these erosions are always the result, primarily, of the direct mechanical irritation or injury caused by the forcible and repeated removal of the slight crusts of inspissated mucus which are formed in the first instance by various accidental circumstances at this point (a slight concavity here is not infrequent), the finger being the common instrument. The epithelial covering of the parts being thus once disturbed, the subsequent steps of the process—constant crust-renewal and gradually deepening ulceration—follow, until perforation of the septum, no infrequent accident, is the result.⁵

SECONDARY EPISTAXIS.—This variety may be either *active* or *passive*. Under the former head may be enumerated those bleedings which occur when for any reason there is a sudden determination of blood to the head. Mackenzie⁶ discredits the old-time view, that the accident may be produced by low atmospheric tension at great heights, and Cloquet⁷ says that it is possible to ascend passively to a considerable height, as in a balloon, without its occurrence.

Passive epistaxis is met with in an inveterate and dangerous form in the subjects of the hemorrhagic diathesis; it also occurs in purpura hemorrhagica, scurvy, and variola hemorrhagica. Mosler,⁸ in eighty-one cases of leukæmia, records sixty-four examples of hemorrhage, and in thirty-five of these the bleeding was from the nose. In influenza, variola, measles, and scarlatina, and in remittent, typhoid, and relapsing fever, it may occur at the inception of the disease, during its course, or as introducing a crisis; more rarely it is seen in acute tuberculosis, trichinosis, and some other similar conditions. In sim-

¹ Transactions of the Mississippi Medical Journal Association, 1881.

² Watson, Diseases of the Nose, page 51. London, 1875.

³ Virchow, Krankhaften Geschwülste, Bd. iii. S. 463.

⁴ Osphrésiologie, p. 550. 1821.

⁵ Lefferts, Medical News, January 28, 1882; Little, New York Hospital Gazette, March 8, 1879.

⁶ Lancet, November 10, 1877.

⁷ Op. cit., p. 560.

⁸ Die Pathologie und Therapie der Leukämie. Berlin, 1872.

ple anæmia it is very common. Mackenzie has seen it occur as a concomitant of a highly plethoric condition in children; but more commonly in those of an ill-nourished, strumous constitution. As the result of a gouty or arthritic diathesis, in children, it is not unknown.¹ At puberty, especially in males, it is very frequent. Furthermore, any morbid condition which interferes with the venous circulation, or increases the pressure within the arterial system, alters the tension in the bloodvessels of the nose, and thus predisposes to passive hemorrhage. Epistaxis due to emphysema, heart-disease (Durozier), or whooping-cough, is thus often seen, and it may likewise depend upon diseases of the kidneys, spleen, or liver. (Boyce.) Pressure upon the venous trunks by tumors of the neck or chest, may also produce like results.

Those passive hemorrhages from the nose which have been termed *vicarious*, possess a peculiar interest. Epistaxis may appear vicariously for other customary hemorrhages, especially those of a hemorrhoidal character, or in place of menstruation, and in both cases may return at regular intervals.² Fricker,³ Obermeier,⁴ and Sommer⁵ all report interesting cases of the latter form. Kussmaul⁶ saw periodical epistaxis in a woman having no uterus. The deductions to be drawn from these observations are, however, it must be stated, denied by Puech,⁷ who shows, from the statistics of one hundred cases, that the nasal mucous membrane is least frequently the seat of a vicarious catamenial flow.

Finally, passive hemorrhage from the nose is said to have sometimes prevailed epidemically,⁸ and that habitual nose-bleed is hereditary in some families, is apparently shown by the observations of Babington.⁹

Symptoms of Epistaxis.—The symptoms of an attack are evident. The patient will complain of a sensation of pressure in the head, sometimes of dizziness and a feeling of warmth, and of fullness and tickling in the nose. The flow having commenced, may proceed from both nostrils, as in scurvy, purpura, etc., or from one only, as is commonly the case, and its amount is very variable; usually it runs in drops, but it may pour out in the form of a small stream. Jets of blood are rarely seen. As a rule it ceases spontaneously, or with simple treatment, in a few moments, but, on the other hand, it may last for hours, or even days, and large quantities of blood may thus escape. Fraenkel calls attention to the fact that hemorrhages dependent upon traumatic causes, or upon diseases of the nose, are much less likely to be accompanied by an abundant flow than those which are caused by other conditions. The blood is of a bright-red color, and coagulates readily. Where the flow is very rapid and prolonged, acute anæmia, with all its symptoms, may arise, and even death may occur. The pulse and appearance of the patient must then be carefully watched, especially if fainting or other evidences of exsanguination are present.

Diagnosis.—There is usually no difficulty in arriving at a correct diagnosis as to the source of the bleeding, especially if a direct inspection of the nasal passage from which it is proceeding be made. The frequency with which it arises from the anterior portion of the nasal septum has been alluded to. Certain conditions may arise, however, to complicate the question of its

¹ Guy's Hospital Reports, 1868, p. 39.

² Fraenkel, op. cit. (Ziemssen), vol. iv. p. 152.

³ Württemberg. med. Correspond.-Blatt, No. 21. 1844.

⁴ Virchow's Archiv, Bd. liv. S. 435.

⁵ Heidelberger klinische Annalen. Bd. x.

⁶ Von dem Mangel, der Verkümmerung und Verdoppelung der Gebärmutter u. s. w. Würzburg, 1859.

⁷ Gazette des Hôpitaux, p. 188. 1863.

⁸ Morgagni, op. cit., lib. i. epist. xiv. 25; Cloquet, op. cit., p. 557.

⁹ Lancet, vol. ii. 1865.

origin. If the hemorrhage be profuse, or if it occur during sleep, while the patient is in the recumbent position, the blood may pass either into the œsophagus, and be swallowed, or into the larynx and trachea. In either case, its subsequent removal can only be accomplished either by vomiting or by coughing, and an attack of hæmatemesis or of hæmoptysis may thus be closely simulated. Köppe¹ relates the history of a case in which bleeding originated in the transverse sinus, and, there being disease of the cavity of the tympanum, the blood was discharged simultaneously through the nose and the external auditory canal. In those rare cases where it originates in either the frontal sinus, the antrum, or the ethmoidal or sphenoidal cells, the diagnosis as to exact locality is extremely difficult. Care is also required when the hemorrhage is profuse, and rapidly fills not only the affected nostril but the pharyngeal space as well. In this case blood appears at the opposite nostril, giving rise to the suspicion that its source is double, and at the mouth also. Finally, hemorrhage from the posterior parts of the nose is not only more difficult to locate, but its symptoms are more liable to be confounded with those of other conditions than when it arises from the anterior portion. In any of these very exceptional instances, careful observation and the history of the case will generally serve to render the diagnosis clear.

Prognosis.—This depends entirely upon the amount of blood lost before the patient is seen, the efficacy and promptness of treatment, and the nature, in certain instances, of the cause which gives rise to the epistaxis. In the great majority of cases, as has been stated, the accident is of a trivial nature, and the means available for its arrest being effectual, no danger is to be apprehended if they are promptly employed. Where, however, the epistaxis is symptomatic of some disease of grave significance, the prognosis will be dependent upon the nature of the latter, rather than upon that of its complication alone.

Treatment.—The *direct treatment* of epistaxis simply resolves itself into the selection and proper application, to the bleeding surfaces, of some one of a long list of either mechanical or medicinal means for the purpose of causing coagulation of the blood, which then, in the majority of instances, serves as a tampon in the nasal cavity, and leads to occlusion of the bleeding vessels.

Unless the hemorrhage be excessive, the simpler means may be first employed, not forgetting here, as in all instances, to reassure the patient, tranquillize his surroundings, and cause him to breathe quietly through the mouth, and to abstain from all efforts at blowing the nose. His position should be erect, with the head inclined forwards. The ala of the affected nostril may now be pressed strongly against the septum, and pressure kept up for a few moments, or the finger may be introduced into the nostril as far as possible, to act as a tampon. (Valsalva, Morgagni.) During either of these procedures, the arm corresponding to the bleeding side may be raised above the head (Négrier), and efforts made to excite spasm of the nasal bloodvessels through reflex action, by applying cold, in the form of ice, to the back of the neck, or even to the scrotum, in men, and to the breasts in women. The use of ice or other cold applications to the exterior of the nose, or to the forehead, and injections, or the pouring of cold water into the nose, are sometimes useful in the lighter cases, by exciting reflex spasm of the bloodvessels; but all injections have the common disadvantage, that they wash away the clots as fast as they are formed. I have in several instances used injections of hot water with good effect. Chapman² recommends the water-bag between the shoulders, the water being at a temperature of 115° F., on the principle of a derivative. Finally, Marin³ states that, as the blood in epistaxis gene-

¹ Archiv für Ohrenheilk., Bd. ii. S. 181.

² Med. Mirror, Feb. 1, 1870.

³ L'Union Médicale, 25 Mai, 1872.

rally flows from one nostril only—and most frequently from the anterior third of one of the nasal fossæ—compressing the corresponding facial artery on the superior maxillary bone, near the ala of the nose, will usually check it. The well-known expedient of inserting a tight paper roll under the upper lip will be remembered. Compression of the common carotid artery upon the bleeding side is also recommended. If these simple means fail, the nasal passage may be tightly packed with small pledgets of lint, fastened to strings to facilitate removal, with plugs of borated cotton, or absorbent cotton medicated with various astringents, or with bibulous paper. Leeper¹ advises the use of soluble bougies containing some styptic, and Thompson and Smyly, the introduction of strips of lint for the purpose of absorbing fluid and favoring coagulation; Curtin² sprinkles these strips with tannin previous to their introduction, and Gilruth³ soaks them in perchloride of iron; but Frank believes that their efficacy depends upon the compression of the parts which they exercise, rather than upon their astringent qualities, and recommends that they be twisted to a large size previous to their introduction. The insufflation into the nares of astringent powders, and the injection of solutions of various astringents, mineral or vegetable, such as alum, iron, zinc sulphate, acetate of lead, gallic or tannic acid, or decoctions of krameria, have long been employed. Créquy⁴ has devised an excellent syringe for injecting the nostril: a canula, $2\frac{1}{2}$ inches in length and with a rounded extremity, is fitted to an ordinary syringe, the canula being perforated its entire length by a series of small holes, in spiral succession, and directed backwards so as to emit small retrograde jets. The injected fluid is thus thrown upon the mucous surfaces of the passage, and does not pass into the pharynx. Injections are, however, if carelessly used, not devoid of danger. Malherbe⁵ reports an instance where death from pulmonary gangrene followed pharyngitis and laryngo-bronchitis, the result of injections of perchloride of iron into the nasal cavities; and Gaillard⁶ details a somewhat similar case.

Should the means thus far alluded to fail in checking the hemorrhage, or should it, for any reason, be deemed desirable not to wait for their somewhat slow action, both the posterior and anterior nares should be plugged. This operation is readily effected by means of a Bellocq's canula; or, in default of this, a flexible catheter, with the stylet removed and a string fastened to its eye, will answer the same purpose and can be used in the same way. Bellocq's canula, the instrument commonly employed, is undoubtedly familiar to every practitioner. The canula having been passed back into the nostril, as soon as the watch-spring which it incloses has been pushed forwards, and its rounded end appears behind the soft palate and enters the pharynx, the double string with which it is threaded is seized and drawn out of the mouth. A graduated, conical compress of lint is now attached to the double string, which is passed through its middle, and being guided in its passage behind the soft palate by the finger, is drawn tightly up into its proper position in the affected naris, by the simple withdrawal of the canula from the nose. The anterior plug is now introduced, and the two ends of the string tied over it, to hold all snug. All possibility of further hemorrhage is in this way effectually prevented. These plugs should not remain in position too long: Gross⁷ mentions that he has seen several cases terminate fatally with low fever and delirium, from systemic poisoning produced by their too long retention. Colles has seen tetanus follow from the same cause, and Habershon⁸ pyæmia.

¹ Dub. Jour. Med. Sci., Nov. 1873, p. 364.

² Lancet, vol. ii. p. 775. 1871.

³ Jour. de Méd. de l'Ouest, tome xiv. p. 108. 1880.

⁴ Courrier Médicale, tome xxxi. p. 238. 1881.

⁵ Op. cit.

⁶ Phila. Med. Times, Aug. 1, 1872.

⁷ Dub. Jour. Med. Sci., Oct. 1877, p. 366.

⁸ Lancet, Feb. 27, 1875.

At the expiration of forty-eight hours, therefore, they should usually be removed, by the use of forceps and probe, and the affected nasal cavity should be carefully syringed out.

To accomplish the same purpose, but to obviate the disagreeable necessity of plugging the nares, as here described, several devices have been introduced. Kuchenmeister uses a rubber tube terminating in a rubber ball; the ball is forced through the nostril into the pharynx, distended with water injected through the tube and retained by a stopcock, and then pulled forwards. Others use a rubber tampon distended with air. Englisch uses two rubber balls connected by a tube; one ball remains at the anterior opening of the nasal passage and occludes it.¹ Frank² suggests that a bag of hog's intestine be moistened, passed into the nasal canal by means of a probe, and then injected or inflated; and, finally, Diday³ extols the use of a thin caoutchouc bag, employed in the same way. The internal use of hæmostatics is not often called for during an attack of bleeding, but it is a common practice to prescribe them if it be at all prolonged. Perchloride of iron, acetate of lead, gallic or sulphuric acid, and opium, are thus employed. Sulphate of sodium is recommended by Heurze,⁴ one or two drachms being given every three or four hours, the object being to increase the density of the blood. For the purpose of causing contraction of the arterioles, ergotine is undoubtedly the best remedy, used either by the mouth or, if time presses, subcutaneously. In extreme cases only is transfusion called for. Mosler relates a case of leukæmic nose-bleed, in which not only the attack, but also the return of the epistaxis, as well as the occurrence of any other hemorrhage, was prevented by this means. Morton likewise details an interesting case of the same nature.⁵

The question may be appropriately raised, in many cases of epistaxis, whether or no it is advisable to interfere at all with the processes of nature. Peyer gives the following rule for the guidance of the surgeon in such instances:⁶ "Plethoric youths in whom an epistaxis is aborted are prone to be attacked by cephalalgia, otalgia, and various catarrhal affections. Any hemorrhage which is accompanied by debility, pallor, and coldness, must be considered as excessive, and in such cases the active aid of the physician is demanded." Mackenzie⁷ tersely sums up other contra-indications. Where there is great venous obstruction, as in cardiac disease, emphysema, cirrhosis of the liver, etc.—or in females where the hemorrhinia is of a vicarious character—there is little demand for precipitate interference unless the bleeding has been very persistent. Examples exist in which mania,⁸ epilepsy,⁹ rheumatism, and dyspnoea,¹⁰ have been cured or greatly alleviated by an attack of epistaxis. On the other hand, not only are immediate and also subsequent local treatment demanded in many instances, but constitutional indications are likewise to be met. An example is afforded in the habitual nose-bleed of anæmia, and others will suggest themselves.

¹ Allg. Wien. med. Zeitung, S. 191. 1875.

² Grundsätze über d. Behandl. d. Krank. d. Menschen, u. s. w., Bd. vi. S. 145. Mannheim, 1797.

³ Weber, Pitha und Billroth's Handbuch, Bd. iii. 1 Abth. 2 Lief. S. 187.

⁴ Compend. d. pract. Med., IV. Auflage, S. 94.

⁵ Am. Jour. Med. Sci., July, 1874.

⁶ De Morbis Narium. Basileæ, 1766.

⁷ Loc. cit.

⁸ Van Swieten, Comment. in H. Boerhaave aphorismos, 1124.

⁹ Hoffmann, De Epilepsia.

¹⁰ Raymond, Traité des maladies qu'il est dangereux de guérir, p. 255.

STENOSIS OF THE NASAL PASSAGES.¹

Aside from the causes which have thus far been mentioned, that may lead to the temporary or permanent occlusion of one or both nasal passages, narrowing or closure of these cavities is dependent upon a variety of abnormal conditions, some of which, chiefly those affecting the nasal septum, are now to be considered. Their general symptoms, aside from those which are due to the catarrhal inflammation of the mucous membrane, probably coexisting, and which have elsewhere been considered, are mainly, if not wholly, dependent upon the obstruction to free nasal respiration, which may exist or occur at any portion of the nasal tract, and they will consequently vary in their gravity and persistency, with the grade and nature of the occluding cause. They may best, perhaps, be studied collectively at this point. The stenosis may vary from a slight impediment only to the free passage of air through the nasal canals, producing in the patient a sensation of uneasiness and discomfort, to complete closure, with its attendant train of evils. Much will likewise depend upon the fact, of whether one or both nasal passages are involved, both as regards the intensity of the symptoms and the seriousness of the results. The latter have been carefully studied by Fraenkel² and others. When occlusion is complete, and in certain instances even when it is only partial, oral breathing becomes a confirmed habit, and the conditions of respiration are thereby materially altered for the worse. The evil effects are soon apparent, not only in disturbances in the respiratory organs and air-passages generally, but likewise in circulatory derangements, impaired quality of the blood, and interference with general nutrition and development, the diminution of the air supply to the lungs being, as Berkart³ has shown, readily demonstrated by listening alternately to the chest of one who breathes through the mouth and to that of one who breathes through the nose. The true function of the nose, aside from the sense of smell, being to warm, purify, and moisten the inspiratory current in its course over the turbinated bones, and before it reaches the deeper respiratory passages, the abolition of this function must necessarily charge the lungs with air which is not only raw and unwarmed,⁴ but which likewise holds in suspension more or less dust, and is perhaps loaded with irritating particles. The dryness of the mouth and throat, the constant hyperæmia, and the predisposition to catarrhal inflammation of the mucous membrane, bear witness to the material disadvantages and results following upon nasal occlusion and enforced oral respiration. Its effect upon the character of the voice is well known, and the peculiar, disagreeable, nasal intonation, will be recognized as a prominent symptom and diagnostic sign of the condition. Meyer⁵ has pointed out that when obstruction is complete, the letters "m" and "n" become perverted into "b" and "d"; and Löwenberg⁶ dwells at some length upon the causes of this substitution. The character of the voice is thus altered for the worse: its quality is notably changed, its head-notes are abolished, and it becomes flat and nasal. Toynbee

¹ Consult also Lennox Browne, On Obstructions in the Nasal Fossæ (British Medical Journal, August 24, 1878); Ziem, On partial or total Occlusion of the Nose (Monatssch. für Ohrenheilk., No. 2, 1879); Ganghofner, The Anomalies and Narrowings of the Upper Air-Passages (Vierteljahrsschrift für pract. Heilk., Bd. cxli. 1879); Roser, On Deviation of the Nasal Septum (Monatssch. für Ohrenheilk., No. 4, 1881); Péan, idem (Centralblatt für Chir., No. 46, 1880).

² Op. cit. (Ziemssen), vol. iv. p. 103.

³ Asthma, its Pathology and Treatment. London, 1878.

⁴ Milne Edwards has shown, by experiment, that it is raised 20° in temperature when respired through the nose.

⁵ Med.-Chir. Transactions, vol. liii. p. 191. London, 1870.

⁶ Les Tumeurs adénoïdes du Pharynx nasal. Paris, 1879.

first demonstrated, I believe, through a series of carefully conducted experiments, the altered condition of atmospheric pressure in the fauces and ears when swallowing with closed nostrils; and Lucae¹ has called attention to the fact, that, when the nose is occluded, every act of swallowing repeats Toynbee's experiments. Both tympanic membranes are thus abnormally stretched, and the continuance of the process can but lead to injurious results as regards the hearing power. The manner in which these changes are produced has also been studied by Roe.² Occlusion, or a stenosed condition of the nasal cavities, when existing in the infant at the breast, possesses a peculiar and pressing significance; here even a simple "cold in the head," with its attendant hyperæmia and swelling of the mucous membrane, creates an element of danger. Both Billard³ and Rayer⁴ have shown us that under these circumstances the proper nutrition of the infant becomes almost an impossibility; every attempt to take and hold the breast is incompatible with the enforced oral respiration; the child, if the attempt be persisted in, soon reaches a point of suffocation which obliges it to desist, and use the mouth for respiratory purposes.

In the coryza of the new-born, then, direct and immediate treatment becomes a necessity. That by means of astringent applications has already been alluded to. Hoppe⁵ uses hollow bougies as dilators, if the narrowing is not extreme, and thus by admitting air to the lungs while the mouth is closed over the breast, renders nursing possible; he also recommends forcible distension of the passages by means of slender forceps, a procedure that will hardly meet with general acceptance. Artificial feeding by means of the œsophageal tube, is advised by Kussmaul in extreme cases, and according to Fraenkel was successfully employed by Thiersch, in the case of his own child. The former author, also, after stating the fact, that a healthy infant during sleep always holds the mouth closed, and relies upon the nose for purposes of respiration, the tongue resting upon the hard palate, shows that, if under these circumstances occlusion of the nasal passages takes place, asthmatic attacks occur as soon as sleep overtakes the patient. Asleep or awake, the vigorous attempts at inspiration, in nurslings affected with coryza, may be followed by acute hyperæmia of the lungs, and herein also may lie the explanation of the sudden suffocative attacks. The violent efforts at inspiration, under these circumstances, have, moreover, been known to produce urgent dyspnoea, through the "swallowing of the tongue," so called. Such instances are reported by Cohen and Stammer, and Bouchut⁶ has also called attention to the fact. Hauner⁷ asserts that such cases have not only been mistaken for, but treated as, true croup. Paroxysmal asthma, and even sudden attacks of asphyxia, are not confined alone to children the subjects of nasal stenosis. Under certain conditions, the same attacks may occur in the adult.

Roe⁸ points out that there are two modes in which nasal disease may provoke an attack. 1. The most frequent form results from a narrowing or occlusion of the nasal passages by hypertrophied tissue or nasal polypi. 2. Another form is induced by disease of the pituitary mucous membrane, unassociated with hypertrophy or polypi. The first, he thinks, is both mechanical and nerve-reflex in its character, whilst the second is purely reflex. It is a noticeable fact, that nasal polypi and hypertrophied tissue,

¹ Archiv der Ohrenheilk., Bd. iv. S. 188. 1867-8.

² Medical Record, April 30, 1881.

³ Traité des Maladies des Enfants; 2e éd., p. 480.

⁴ Note sur le Coryza des Enfants à la Mamelle. Paris, 1820.

⁵ Neue Zeitung für Med., 1850.

⁶ Traité prat. des Mal. des Nouveau-nés, 5e éd. Paris, 1867.

⁷ Jahrbuch für Kinderheilkunde, V. Jahrg., S. 73. 1862.

⁸ Report of Annual Meeting of the American Medical Association, June, 1883.

when inducing asthma, are almost invariably located on the posterior end of the turbinated bone, the area that has been likened by Dr. Mackenzie to the sensitive cough-centres found in the pharynx and larynx. This fact explains the more frequent occurrence of asthma at night in those persons who suffer with hypertrophic nasal catarrh. At the posterior end of the inferior turbinated bone, the cavernous erectile tissue is much thicker and more dilatable than at the anterior; consequently, when in the recumbent position, the gravitation of fluid distends this portion of tissue, and, together with the accumulation of secretion, occludes the passage; or reflex irritation of the air-passages results, and the attack comes on. Dr. Roe appends several cases in which treatment applied to the nose cured the asthma. He advocates removal of the hypertrophied turbinated bones by the nasal bone-scissors, and of the hypertrophied tissue by Jarvis's snare.

Traube¹ relates two interesting cases in which every inspiration was accompanied by a pressing together of the *alæ* of the nose, instead of a normal dilatation, causing nasal stridor and difficult respiration. This phenomenon he attributes to the beginning of paralysis of the respiratory nervous system, and regards the condition as a fatal one, unless properly treated.

Still further but less serious results affect the nasal organ directly when its passages are rendered more or less impermeable. These need but be alluded to. The inspired current of air is unable, in many instances, owing to the amount of obstruction presented to its entrance, to penetrate to the upper part of the nasal cavities and reach the seat of the distribution of the terminal expansions of the olfactory nerve. The sense of smell is thus blunted in direct proportion to the amount of interference with the entrance and passage of the air current charged with odoriferous particles. The same obstruction, again, by preventing or interfering with the expulsive force of the expiratory current, prevents the removal of the usually abnormal amount of secretion, either by blowing the nose or otherwise; its accumulation is in turn an efficient factor in producing obstruction; and a "vicious circle," as it has been termed, is thus established. The symptoms, then, of nasal stenosis may be thus summarized: inability to breathe through the nose, and consequent impairment of the sense of smell, with its accompanying absence of the perception of flavors, hoarseness and disturbance of speech, respiratory obstruction, asthma, sudden asphyxia, inability to remove the nasal secretions, dryness of the pharynx, a sense of fulness and pressure about the nasal and frontal regions, more or less persistent frontal headache, weakness of the conjunctivæ, a constantly open mouth—altering, in children, the cast of the countenance—and, finally, a predisposition to catarrhal inflammation of the respiratory mucous membrane upon the slightest exposure, or on any unfavorable change in the weather. As giving rise to the physical conditions which produce the results here described, a number and variety of causes, as has been stated, can be enumerated. Some, mainly those dependent upon the results of catarrhal inflammation of the nasal mucous membrane, have already been considered. Others still remain, of even more serious import, and will be discussed in detail.

CLOSURE OF THE NOSTRILS.

Closure of the nostrils may be the result of either congenital malformation, disease, or accident. The former is rare, much rarer than like conditions in either anus or vagina. In the reported instances, there has either been an adhesion of the *ala* of the nostril to the septum, or it has been drawn down

¹ *Verhandlg. der Berliner med. Gesellsch.*, Bd. ii. S. 141. 1869-71.

and attached to the upper lip; a continuation of the normal integument has covered in the nostril or nostrils, or the latter have been blocked up by a firm membrane. The effects of such occlusion are apparent. Fortunately, treatment is usually a simple matter, and the earlier it is undertaken the better. A simple, direct incision is often all that is needed, the opening thus made into the nasal passage being kept open and dilated by means of a strip of lint, until the healing process is completed. Where some deformity of the parts coexists with the occlusion, a more extensive dissection of tissue may be necessary. A like condition, the result of accident or disease, is more frequent; a common cause, of which I have seen and successfully treated two instances, is the loss of tissue and subsequent cicatricial contraction about the nasal openings following *smallpox*. Deep *burns* of the face produce the same result, and *fractures* of the nose, with laceration of the soft parts, and subsequent contraction during the healing process, are a like efficient cause. As a rule, in such instances, a small opening through the adventitious tissue will be found to exist, and may be simply dilated by means of compressed sponge, laminaria, or metallic bougies. In certain cases this treatment must be supplemented by incisions, the nature and direction of which depend upon the deformity in the particular instance in which they are undertaken. Constant repetition of the dilating process will always be found necessary to prevent recontraction.

AFFECTIONS OF THE SEPTUM.

The septum itself is liable to various affections, which play an important part in producing either temporary or permanent stenosis.

EXTRAVASATIONS OF BLOOD¹ occur, as the direct result of injury, beneath the mucous membrane on one or both sides of the cartilaginous portion of the septum. The resulting tumor is frequently large, with a broad base, and of a dark, congested color; the surrounding induration and the tension are marked, and often mask any sense of fluctuation. The rapidity with which the tumor forms after the accident, and the history of the case, with direct inspection of the parts, render the diagnosis easy. Inflammation and suppuration may generally be prevented, and resorption facilitated, by the adoption of strict antiphlogistic measures. Incisions are not often required—never unless the amount of extravasated blood be large and the obstruction to nasal respiration great.

ABSCESS OF SEPTUM.—Should these measures fail, acute abscess of the septum may result. Although this condition is usually the direct result of injury, and is not preceded by any marked extravasation of blood—I have never seen it arise spontaneously, in connection, for instance, with scrofula, or subsequently to the exanthemata, smallpox, measles, or scarlatina—the attendant tumefaction and inflammation are not always confined to the nasal cavities, the whole nose, cheeks and neighboring parts being not infrequently involved, especially at an early stage of the process. The tumor in the nose, which is always—apparently, at least—bilateral, presents a smooth, reddish appearance, is tender on pressure, and is seen at the lower part of the septum, shading off above and behind into the contiguous mucous membrane. Fluctuation is distinct, and is often felt on both sides of the septum, and through it; the latter is always the case if there is perforation of the carti-

¹ Fleming, Dublin Quart. Jour. Med. Science, vol. iv. pp. 16–28.

lage, a not unusual result, especially if treatment has been delayed. I have never seen the inflammation spread to the frontal sinus or lachrymal passages. With this condition there is some febrile movement, and much local pain and distress. The treatment consists in opening the abscess by direct and free incision, with thorough evacuation of its contents. The longer the delay, the greater is the risk of the periosteum or the perichondrium being involved, with resulting necrosis. The incision, which rapidly closes, must be kept open for a few days until tumefaction has subsided. Bad results do not follow, even in cases where the cartilage has been perforated; the mucous membrane heals kindly over the small loss of substance without leaving any external deficiency.

Acute abscess complicated with a small aneurism has been observed by Thudichum¹ in one instance. In opening the abscess the aneurism was also opened, and the free bleeding could only be checked by means of the galvano-cautery.

Chronic abscess of the septum, with perforation of the cartilage, may occur in syphilitic or scrofulous subjects, and may even exist without known assignable cause. It is unilateral, its progress is slow and insidious, and its symptoms slight, the patient often being unaware that it exists; no marked inflammation accompanies it, and, externally, the nose gives no evidence of its presence. The ulcerative destruction of the cartilaginous septum which follows, is, however, serious, and one large orifice or several small perforations result, the former being the rule. Such cases are not unfrequently examined long after the subsidence of all of the symptoms, and when the existence of the perforation through the septum is the only guide to the surgeon as to the nature of the earlier affection. Perforation of the nasal septum, it may here be remarked, should not always be regarded as syphilitic in its origin, the result of the breaking down of a gumma. In many instances, probably, the true cause lies in the direct mechanical irritation caused by the patient, usually the subject of nasal catarrh, in constantly endeavoring to remove hardened secretions from the anterior portion of the septum. Such cases are not at all uncommon, and are elsewhere alluded to in this article. I cannot believe, with Cohen, that there is even a probability that, in a fair proportion of instances, the perforation has resulted during the course of a syphilitic coryza which has occurred in early infancy. Still less do I believe that these perforations are congenital, even though they be met with independently of any history of local disease within the patient's memory.

Early incision of these abscesses is imperative, and a guarded prognosis should be given. Perforation of the septum is the rule; and, although no external deformity of the nose has ever followed in my experience, the condition is one that, in many respects, is disagreeable in its results. Plastic operations for the closure of the deficiency, although they have been undertaken, are rarely if ever attended with success. Constitutional treatment, suitable to the indications presented in individual cases, is all-important.

SYPHILITIC INDURATION of one or commonly both sides of the septum, due primarily, in all probability, to disease of the perichondrium, without any marked inflammatory symptoms, and with no evidence at any part of its course of the formation of abscess, may exist, and may constitute an efficient cause of nasal obstruction. I have met with it in several instances. The diagnosis rests mainly upon the indurated character of the swelling, and upon the absence of all signs of excessive inflammation. Its differentiation from cartilaginous outgrowth of the septum, and even from deflection of the cartilage, should the induration be unilateral, demands some care. Its rapid

¹ Lancet, April 17, 1880.

subsidence under the use of an anti-syphilitic treatment is the rule, and confirms the diagnosis. I have had no experience in the injection into the substance of these swellings, of solutions of iodine and iodide of potassium, ergot, or carbolic acid. External applications are of little avail.

SUBMUCOUS INFILTRATION OF THE SIDES OF THE SEPTUM, to which attention was first called by Cohen,¹ is a not unusual complication in a large proportion of cases of chronic catarrhal inflammation of the nasal mucous membrane, and, if excessive, produces in a marked degree the symptoms of nasal stenosis. An examination with the rhinoscope shows that a tumid mass exists on either side of the septum and is confined to its posterior portion, of a whitish color, that is markedly distinct from the red color of the adjacent mucous membrane; it does not always, as asserted, occupy the lower portion of the septum, extending thence upwards, the reverse being, to say the least, very commonly seen. The affection is usually symmetrical; the masses are ovoid in outline, and much resemble nasal polypi. They appear to be œdematous projections of the mucous membrane from accumulation beneath it of serum, sero-mucus, or fibrin, and are best treated, according to Cohen, by tearing away portions of the masses by forceps carried up behind the palate, or introduced through the nostril, as the case may best permit, the operation being performed under the guidance of the rhinoscopic mirror. Hemorrhage is slight. The parts, after the operation, should be cauterized. Sometimes puncturing these masses with a curved lancet suffices. Finally, the galvanocautery affords an appropriate means for their destruction.

DEFLECTION OR DEVIATION OF THE SEPTUM from the normal, median line, may be due to an abnormality, not uncommon in either its bony or cartilaginous portions, or may occur as the result of a fracture or displacement of the septum, the effect of direct violence.² In such cases, the cartilaginous septum is that which is most frequently displaced, and usually at the point of its articulation with the bony septum; next in point of frequency, the perpendicular nasal plate is broken, and especially where it approaches the vomer. The force of the concussion rarely reaches the latter, the perpendicular plate giving away first and easily. Proportionate to the amount of displacement will be the degree of obstruction to the nasal passages; a depression of the cartilage forming the ridge of the nose is necessarily accompanied with a corresponding degree of lateral displacement, with or without fracture of its perpendicular portion, and produces therefore not only great deformity, but sometimes complete flattening of the end of the nose, aside from complete obstruction of the nostrils.³ The results of such fracture and displacement must not, however, be confounded with a deflected septum the result of congenital or acquired abnormality. The clinical history will assist in making the differential diagnosis. As a matter of fact, the nasal septum is rarely found perfectly straight, but exhibits a slight inclination either to one side or the other, usually the left. Owing to its composite nature, its errors of position are furthermore not of one kind; thus, deviations occur in the perpendicular plate of the ethmoid bone, at the ethmo-vomerine suture, and in the superior maxilla; and in the living subject they are also seen, and very commonly, in the triangular cartilage. All of the above-mentioned forms may exist separately, or together. The frequency of these deviations from the normal standard is shown in a study by Allen⁴ of 58 adult crania; of these, only 18 exhibited normal nasal cavities, while in the remaining 40, 19 were found in

¹ Diseases of the Throat, 2d edition.

³ Hamilton, Fractures and Dislocations, 3d ed. 1866.

² See page 801, *infra*.

⁴ Am. Jour. Med. Sci., Jan. 1880.

which the curvature was so great as to cause the septum to lie in contact with the superior and middle turbinated bones; and Semeleder, in an examination of 49 skulls, found that the septum was straight in only 10, bent towards the left in 20, towards the right in 15, and in 4 was so twisted that it resembled the letter S in shape.

As a rule, the deflected part will be found to affect principally the cartilaginous septum, and to exist at the anterior portion of the latter. Such deviations, however great they may be, but rarely deform the external contour of the nose. When excessive, as the patient develops, the abnormality in the position of the septum turns the nose to one side, and narrows or occludes one or both nostrils. Although probably, in the majority of instances, the conditions here described are congenital, there can be no question but that, in certain cases, deflection or deformity is produced by the common practice of pressing more firmly on one side than the other in blowing the nose. Bécларd explains it by the habit of wiping the nose with the right hand, the deflection being more often to the left than to the right. Be the cause as it may, the condition is an exceedingly common one, and if excessive, it produces such an amount of nasal obstruction, and gives rise to such distressing symptoms, that surgical treatment for its relief is always indicated. Diagnosis is not difficult; the appearance of the occluding mass and its feeling to the touch establish its nature, and this is further shown by an inspection of the unaffected cavity of the nose, which will show a concavity corresponding to the convexity upon the narrowed side. The cure of the condition is attained by various means, all having however for their object the replacement of the cartilaginous septum in the median line, and its retention there, or the removal of the offending portion.

Chassaignac¹ resorted to subperiosteal resection of the deviated portion. An incision was made through the mucous membrane in an antero-posterior direction, low down towards the floor of the nostril on the affected side; the membrane was raised from the cartilage by means of a small spatula, and the convexity of the cartilage then cut away in slices until sufficiently thinned to allow of its being pushed back into its normal position; the mucous membrane was then replaced, and the cartilage held in its new position by a sponge inserted in the nostril. Rupprecht,² when the deviation is caused by an abrupt curve or bulging, uses a sharp pair of forceps with blades so arranged as to cut out the affected portion of the septum; a communication is thus established between the two sides of the nasal cavity, and, according to the inventor, the permeability of the closed side is also restored. Blandin³ perforates the septum in the deflected portion with a like punch. Steele⁴ makes a stellated division of the mucous membrane and cartilage, then forcibly replaces the divided septum, and retains it in position by ivory or wooden plugs introduced into the nostrils. The division of the cartilage destroys in a great measure its resiliency, and the plugs are more to give support than to exert pressure. The instrument by means of which this is effected is a stout forceps, shod on one blade with knives set in stellar form; the two blades are united after the manner of obstetrical forceps, to facilitate introduction and withdrawal. The great advantage of the latter operation is, that it takes no portion of the septum away, as is the case in both of the former; and though deformity of the nose never follows the removal in these instances of a small portion of the septum, the effects of the resulting artificial perforation are disagreeable in numerous ways (whistling noise during

¹ Gaz. Hebdom., 11 Juin, 1869.

² Wien. med. Wochensch., S. 1157. 1868.

³ Dict. Encyclopéd. des Sciences Méd., art. Nez.

⁴ Archives of Laryngology, vol. iii. No. 1.

respiration through the nose, constant collection and drying of the secretions upon the edges of the perforation, tendency to superficial ulceration, etc.), and should therefore be avoided if possible. Pancoast has separated the cartilaginous from the bony portion of the septum by subcutaneous division with a tenotome, and then replaced it in its normal position, pulling the nose to the opposite side and holding it with adhesive strips. Other surgeons have divided the nose in the median line and resected the septum. The indications presented in individual cases must guide the operator in his selection from these means.

If the obstruction is due to a deflection or displacement of the cartilaginous septum, involving its whole or nearly whole length, the most successful operation for correcting it is probably that proposed by Adams.¹ In this method, the bent portion is forcibly broken or straightened by means of powerful forceps with parallel blades, one of which is introduced into each nostril; and when the nasal bones are displaced laterally and likewise depressed, these are raised also by carrying the blades of the forceps directly upwards. After the nose and its cartilage have thus been straightened, a retentive apparatus is employed, consisting of a steel screw-compressor, applied so as to support the septum; and, subsequently, ivory plugs are used to keep the nostrils moderately distended and to give support to the cartilaginous septum, not only during the healing process, but likewise for a time afterwards.

In conclusion, certain less heroic measures need but be alluded to: the simple insertion of metallic tubes in the nasal passages, thus exercising gentle dilatation and some compression, and the use of sponge tents, or of laminaria bougies, may, if their use be persisted in, especially in young subjects, bring forth good results, provided that the amount of deviation is not excessive.

FRACTURES AND DISLOCATIONS OF THE NASAL SEPTUM.—The treatment of these injuries is usually discouraging, as they are commonly followed by permanent deformity, which is, however, rarely great. Hamilton doubts whether a partition so thin and unsupported, can ever be well adjusted and maintained by artificial means, but advises that each nostril should be plugged carefully and equally with pledgets of lint, and the outside of the nose then covered completely with a nicely-moulded gutta-percha splint or case, which ought to be made to press snugly upon the sides; these dressings should be permitted to remain for several weeks, or until the cure is completed. This mode of procedure must be modified and varied to suit individual indications.

Fracture of the nasal septum, if extensive, and unless carefully treated at the time of the accident, may by its displacement and subsequent deformity seriously occlude the nasal passages. A common form of the lesion is the tearing away and lateral displacement of the cartilaginous septum from the bony, at their point of junction. The treatment must consist in the accurate readjustment of the displaced parts by intra-nasal and extra-nasal manipulation, and their retention by means of mechanical supports, probably within the nasal passages. If the septum be broken into several pieces, as is sometimes the case, their immediate removal is indicated; and under any circumstances, if reposition cannot be effected, and if the subsequent deformity be sufficient to occasion occlusion, the offending parts may be cut away.

TUMORS OF THE SEPTUM, aside from the *osseous* and *cartilaginous* outgrowths which not infrequently affect it, are rare. The former are the least common, and are only met with far back in the nasal passage, over the bony portion of the septum. They are more or less linear in shape, stretching in an antero-

¹ British Med. Jour., Oct. 2, 1875.

posterior direction, sometimes with a sharp exterior edge, at other times more flattened; upon their size depends the amount of nasal obstruction that they cause, and their true nature may usually be at once appreciated from their density and their location.¹ The cartilaginous outgrowths or thickenings, on the other hand, occur anteriorly in the nasal fosse, and, for the most part, are attached by broad bases to the septum and adjoining parts of the floor of the nose. Their removal, if indicated, is readily accomplished. I have been in the habit of slicing them off, as it were, from the septum, by means of a long, strong, probe-pointed knife; the incision is easily made; the removal, if the knife is kept parallel to the septum, is thorough, and the result good; the wound of the mucous membrane heals over kindly. When an exostosis or spiculum of bone projects from the side of the vomer, it must be of necessity removed by means of a small chisel, the patient being anæsthetized, or by the small, double gouge-forceps devised by Weir.² Goodwillie³ recommends for the same purpose, the use of the surgical or dental engine, drilling away the bony mass by the revolving multiple-knife inclosed within a sheath. Cohen has reported a case of exostosis from the palatine ridge of the superior maxilla and vomer, occluding the right nostril, which he removed with the burr of the dental engine⁴, and Pomeroy⁵ gives a similar instance. Of the other forms of tumor, *papilloma* is, perhaps, the most frequently encountered.⁶ The growths generally occur just above the orifice of the nostrils, and spring from the mucous membrane of the septum at this point. In five instances that I have met with, the tumors have been small, and always unilateral, and have occurred in young persons, giving rise to some obstruction of the nasal passage, but notably to recurrent attacks of epistaxis. In a sixth case, recently seen, the tumor grew from the anterior extremity of the right inferior turbinated bone; it is the only one that I have ever seen in this locality. The general resemblance of these tumors to papillomata of the mucous membrane of other parts, renders their recognition easy, and as they may be easily and effectually removed by the knife, snare, or scissors, their occurrence is a matter of more interest than importance. *Gelatinous polypi*, true myxomata, are occasionally encountered springing from the side of the septum.

Cohen is authority for the statement that *cystomata* sometimes occur in the same situation. The treatment consists in evacuation of the colloid contents of the sac, by incision, and in local medication of its walls so as to excite adhesive inflammation. Van Vadj⁷ has seen a case of *sarcoma* of the nasal septum in a male syphilitic subject, and Mason⁸ one of *myeloid* tumor.

CONGENITAL OCCLUSION OF THE POSTERIOR NARES is a rare affection. Its subjects are, as a rule, very young children, and the obstruction to nasal respiration makes itself manifest soon after birth, upon attempts being made to suckle the infant. The attendant symptoms—difficult respiration, frequent suffocative attacks, and mucous discharge—persist, should the child survive, into later years. Several cases are reported in medical literature. In Emmert's⁹ patient, a boy of seven, the nose was well formed, but the choanæ were closed by a bony wall. He had never breathed through the nose, and had been nourished as an infant only with the greatest difficulty. Fraenkel¹⁰ demon-

¹ See Michel, *Gaz. Hebdom.*, 1873.

² *Medical Record*, March 13, 1880.

³ *New York Medical Gazette*, July 31, 1880.

⁴ *Medical and Surgical Reporter*, July 13, 1878.

⁵ *Medical Record*, June 11, 1881.

⁶ See Féré, *Bull. Soc. Anat. de Paris*, tome iv. p. 587. 1880; Maiocchi, *Gaz. Med. di Roma*, t. iv. p. 265. 1878; Delavan, *Archives of Laryngology*, vol. iii. No. 2.

⁷ *Wien. med. Presse*, 18 März, 1877.

⁸ *Lancet*, April 29, 1876.

⁹ *Lehrbuch der Chirurgie*, Bd. ii. S. 355. Stuttgart, 1853.

¹⁰ *Ziemssen's Cyclopædia*, vol. iv. p. 113.

strated in a like case, in a young man, the existence of a smooth and solid bony wall, covered on both sides with mucous membrane, occluding the right naris posteriorly. Cohen¹ does not state the nature of the obstruction in the case of an infant which he successfully treated. Voltolini operated with the galvano-cautery upon a total occlusion of the right posterior naris, due apparently to congenital adhesions, and long mistaken for nasal tumor. Bitot² has seen an instance, in a fetus of seven months, in which the atresia or obturation of the posterior orifices of the nasal passages was due to the presence of two triangular bones, articulating above with the sphenoid, below with the horizontal plates of the palatine bones, to the outside with the lesser wings of the pterygoid processes, and impinging on each other interiorly. An equally reliable and close post-mortem observation has been made by Luschka³ on the cadaver of a girl who died soon after birth. Here the bony framework was formed by the palatal bones on both sides. The posterior, normally free and concave border of the horizontal plate was continued in a somewhat oblique direction upward and backward, to the lower surface of the body of the sphenoid bone, being attached to the latter by a serrated edge. Laterally, the bony plate reached the inner side of the lamina interna of the pterygoid process. In the median line, the lamella joined its fellow at the point where the posterior nasal spine usually arises, while the two, in their further progress upwards, were separated by a very narrow slit, into which the lower extremity of the rudimentary vomer had penetrated. More recently, instances of congenital occlusion have been reported by Gosselin,⁴ Morton,⁵ Brandeis,⁶ Wilkinson,⁷ and Ronaldson,⁸ the cause in the last surgeon's case having been a thick, firm membrane. Koch reports a curious case, which may be mentioned here, viz., one of cicatricial closure of the right posterior naris, following a serofulous pharyngo-laryngitis;⁹ and, finally, Mackenzie¹⁰ relates the following case:—

The naso-pharynx was separated into two lateral halves by a thin bony partition, continuous anteriorly with the posterior edge of the vomer, and inserted posteriorly into the posterior pharyngeal wall. Superiorly it became fused with the pharyngeal vault. The septum narium was slightly deflected to the left from before backward; the bony lamella had a similar inclination, and seemed to be in fact a backward prolongation of the vomer. Its inferior edge was more or less sharp, clearly defined, and curved from before backwards and upwards, presenting a very marked resemblance to the normal posterior curve of the nasal septum. Its insertion into the pharyngeal wall was on a higher plane than that of its origin, which corresponded with the inferior edge of the septum. Attempts were made to dislocate it, but without success.

The indication for treatment lies in establishing, by surgical means, an opening through the affected nasal passages, at as early a date as possible. In the case of membranoid occlusion, this may easily be accomplished by means of the knife and subsequent use of bougies, to dilate and keep open the artificial perforation. In Cohen's case the occluding structures were bored through with a knife and steel probe, and the passage kept open and enlarged, from time to time, by the insertion of a sound, and subsequently of small bits of sponge fastened to a holder. When the occlusion is of a dense and bony nature, the employment of the burr of the dental-engine, elsewhere alluded to, suggests itself as the best, quickest, and safest means of perforation.

¹ Diseases of the Throat, p. 385. 1879.

² Archives de Tocologie. Sept. 1876.

³ Der Schlund-kopf, S 27. Tübingen, 1868.

⁴ Gazette Méd. de Paris, No. 36. 1877.

⁵ Surgery in the Pennsylvania Hospital, p. 333. Phila., 1880.

⁶ London Med. Record, April 15, 1882.

⁷ North Carolina Med. Journal, vol. ix. page 305. 1882.

⁸ Edinburgh Medical Journal, vol. xxvi. page 1035. 1880-1

⁹ Ann. des mal. de l'oreille et du larynx, No. 4, 1878.

¹⁰ Archives of Laryngology, vol. iv. No. 3.

BIFID SEPTUM.—A curious abnormality of the posterior nares, of which I am aware of but two instances, those reported by Schroetter¹ and myself,² is as follows: The posterior edge of the septum narium, from its point of mergence into the parts making up the vault of the pharynx to one-half way in its course from the floor of the nares, is divided vertically into two distinct halves, inclosing between them a small space; this space is more or less triangular in shape, its base lying above, and is lined apparently with normal mucous membrane. This description applies to both of the instances mentioned. In neither was there any history of injury or disease; the condition gave rise to no symptoms, and was discovered only by accident, during rhinoscopic examination.

FOREIGN BODIES IN THE NASAL PASSAGES.

Articles of the most varied character, form, size, and description, are not infrequently found lodged within the nasal fossæ, either as the result of accident or design; especially is the latter the case in children. Fraenkel, moreover, calls attention to the fact that foreign bodies may originate within the organism, having their source, in such cases, first, within the nose or neighboring cavities—as for instance, in the detachment of necrosed bits of bone—or second, originating elsewhere in the body, carried into the nasal cavities, and lodged there: as examples may be quoted, the entrance of part of the contents of the stomach through the posterior nares into the nostrils, in violent attacks of vomiting, and the occasional presence of the *ascaris lumbricoides* within these or the contiguous cavities. Thiedemann³ has collected a number of cases in which the lumbrici, having reached the stomach, passed out of the body by the nose instead of the mouth, or even remained for some time in the former, causing by their presence great local disturbance.

If the foreign body come from without, it has but three points of entrance: first, and most commonly, through the anterior nares; second, but rarely, through the posterior nares; and finally, infrequently, through the soft parts of the face, as is seen in gunshot wounds, accidents of various kinds, stab-wounds, etc.⁴ The latter two classes, from their infrequency, need but passing mention. Lowndes⁵ reports the case of a ring—too large to have passed in through the anterior nares—as having been lodged in the post-nasal cavity, where its presence could only be accounted for by its having been swallowed and passed into the nose from the lower pharynx; and Noyes has removed the entire breech-pin of an exploded gun from the nasal cavity, where it had long lain undiscovered, the patient having applied to Dr. Noyes for treatment of his eyes.⁶ The catalogue of the foreign bodies introduced into the nostril through its anterior opening, forms an interesting and curious, but illimitable list. Buttons and glass beads are favorite articles with children. I have removed carpet-tacks, nuts, small pebbles, copper rivets, bits of wood, pieces of coal, shot, pins, and beans; in the case of the latter, germination is possible, although I have never seen it.

The foreign body once introduced, if discovered by the attendant, or its introduction acknowledged by the patient, is usually quickly removed, if efforts looking towards that end are at once made by the surgeon; on the other hand, if forgotten and undisturbed, it not unfrequently remains *in situ* for years, covered

¹ Laryngologische Mittheilungen. Wien, 1875.

² Med. News, Jan. 7, 1882.

³ Von lebenden Würmen und Insekten in den Geruchs-organen des Menschen. 1844.

⁴ Cloquet, Osphrésiologie. Weimar, 1824.

⁵ British Medical Journal, September, 1867.

⁶ See also Lancet, May 3, 1884.

probably with phosphatic deposits, keeping up a constant irritation, mucopurulent discharge, and offensive smell, and not very rarely being mistaken for carious bone, the result of struma or syphilis. Two such instances have come under my observation. In one, the foreign body, a shoe button, thickly covered with calcareous matter, had lain undisturbed for some eighteen years, having been introduced by the patient when a child, a fact distinctly remembered when its presence was demonstrated. In the second, a bean, likewise encrusted, was removed after a sojourn of some fifteen years. In both cases, all the symptoms of fetid catarrh were present. The presence of a foreign body had been demonstrated, and, through the supposition that this was necrosed bone, both patients had been for some time under anti-syphilitic treatment. No attempt at the removal of the foreign body had been made in either instance.

The *symptoms* caused by the presence of a foreign body within the nose, vary naturally according to the duration of its stay, as well as upon its irritating or non-irritating nature and form. If the latter be sharp, irregular, or pointed in character, considerable inflammatory reaction will follow its entrance into, and impingement upon, the nasal mucous membrane, while a smooth, rounded body, on the contrary, will give rise to little or no local disturbance. As a rule, the symptoms in recent cases are simply those of an ordinary chronic coryza, with abundant purulent discharge, and the results of the occlusion of a nasal passage. Should, however, the foreign body be of such a nature that it imbibes moisture from the nasal walls, and swells within the bony inclosure in which it lies, to these symptoms must be added those due to the pressure and tension that it causes, viz., pain, severe headache, and distortion of the nose. Should its sojourn be one of months or years, all the symptoms of a fetid catarrh will probably be developed, as in the instances above reported; and in cases where the foreign body is sharp and irregular, ulceration of the mucous membrane at its point of lodgment, with bloody discharge at times, and increased pain, will be the rule, and will still further complicate the existing conditions.

The *diagnosis* of a foreign body within the nostril is greatly assisted by the statement of the patient, if this can be obtained; in default of it, it must rest upon the results of inspection and palpation. The foreign body being usually obscured by a thick coating of mucus, a thorough washing out of the affected nostril will be found desirable as a preliminary to the use of the probe. Much valuable information may thus be obtained as to its nature, form, and method of lodgment. The probe, carefully used, establishes the fact of its existence. It can be but confounded with one condition, viz., necrosed bone. The mobility of the object, the character of its surface, and the peculiar sensation conveyed to the finger by the probe on touching it, will always serve to differentiate the substances. It is hardly necessary to add, that in default of a clear clinical history of the presence of a foreign body, a careful examination should be instituted in every case of offensive discharge from the nares, attended by symptoms of occlusion, both by anterior inspection and by the use of the rhinoscopic mirror.

The *treatment* of a foreign body within the nares lies in its removal at as early a date as possible after its entrance. To do this will often tax the inventive ingenuity of the surgeon. Small, loose bodies may sometimes be quickly expelled by exciting sneezing in the patient; blowing strongly into the unaffected nostril, is also said to expel the offending substance from the other. King gives an instance of the expulsion of a cherry-stone from the nose during the action of an emetic, the mouth being held closed at the moment of emesis. Success may be obtained by the injection of a powerful stream of water through the nares, either anteriorly, by means of a large syringe held to the

unoccluded nostril—the best method—or by the use of the nasal douche, the can being well elevated to render the pressure strong; or the posterior nasal syringe may sometimes succeed in driving out the foreign body, if it be not firmly impacted, by the mere mechanical force of the stream of water. Cohen recommends that curved bougies or probes be passed up behind the velum into the occluded nostril, and the foreign body thus pushed forwards. He also alludes to the method pursued by aurists to remove bodies impacted in the external auditory meatus—by placing a brush, loaded with glue or other adhesive fluid, in contact with it, and allowing it to remain until firmly adherent, so that the brush can be used as a tractor—as applicable in the removal of certain classes of foreign bodies from the nose. When the foreign body is large, and perhaps firmly imbedded in the soft parts, it must be seized directly by means of the fenestrated scoop, slender hook, curved probe, or small, slender forceps, made in two distinct portions which may be introduced separately, one on each side of the foreign body, and afterwards locked together like midwifery forceps.

Some care, and a little attention devoted to the peculiarities of each case that may be treated, will render easy the choice of the special instrument best adapted to the extraction of the foreign body. For instance, I have on a few occasions been able to hook a small probe into the eye of a button firmly fixed in the nostril, and thus readily remove it. The forceps would have but pushed it further into the nasal passage. The latter is a not unfrequent occurrence, which renders subsequent efforts at removal anteriorly even more difficult. Even with care, it is sometimes not to be avoided, and the question arises, when, from its location, size, and impaction, a foreign body cannot by any gentle means be removed through the anterior nares, whether it should not be pushed backwards into the pharynx, either there to be caught and extracted, or, as is commonly the case, to be swallowed and afterwards discharged by the rectum. My own experience is, that when necessary (I do not hold that it is desirable) this may be done with impunity. I have never met with the danger so forcibly alluded to by some writers, viz., that of the foreign body falling into the larynx; nor have I found it necessary to follow their advice and protect the entrance to this organ. The results where I have followed out this plan of treatment, unsurgical I admit, have been favorable. In a case reported by Morrman, a foreign body, lodged far back in the nasal passage, was pushed forwards within reach of the forceps by closing the mouth with the hand, so as to cause the patient to breath alone through the nose. In rare instances, where extraction is impossible by any of the above means, it may be necessary to gain direct access to the point of impaction by means of some form of external excision. The operations that have been employed are: the division of the wing of the nose (Vidal); division in the median line (Dieffenbach); and raising the whole nose by means of an incision through the gingival margin of the upper lip, and thence dissecting upwards (Rouge). Finally, to proceed to the other extreme, Watson alludes to the possibility of leaving the foreign body to be extracted, partly by nature's efforts and partly by the assistance of art. In process of time ulceration will take place around it, and this will have the effect of loosening it from the bed in which it has been so tightly wedged; then, by using the douche apparatus through the opposite nostril, it may be dislodged and expelled.

NASAL CALCULI, OR RHINOLITES.

Calcareous concretions are occasionally encountered in the nasal fossæ, their origin, probably, being always due to hard foreign bodies which have been

forced into these passages at dates long antecedent to their discovery, and which have in process of time become nuclei for deposits consisting, according to Demarquay,¹ of phosphates of lime and magnesium, chloride of sodium, and the carbonates of lime, magnesium, and sodium—in other words, essentially the sediments of the saline portion of the serum of the blood. Numerous cases may be found scattered through medical literature, in some of which the calculus has attained an extraordinary size, even that of a pigeon's egg, weighing three or four drachms. Many of the earlier cases are cited by Demarquay, in his elaborate work. Bartholin, quoted by Cloquet,² relates the instance of a young woman, who, after suffering a long time from headache, passed from her nose several calculi, which, in size and shape, resembled date-stones. Clauder witnessed the case of a woman, who expelled from her nose, a very hard, round concretion, as large as a hazel-nut. Khern mentions several pisiform calculi which had escaped from the nostrils of a young person suffering from a violent headache. Riedlin, D'Ulm, Buchner, Plater, Watson, and others, add similar instances. Savialles informs us of a case of the same kind, which had for its nucleus a foreign body introduced into the nose from without. Some remarkable cases are to be found in the Contributions to Pathology and Surgery³ of Mr. Hawkins. Roe⁴ reports an instance occurring in a young woman, in which the rhinolite weighed, after removal, forty grains. Two instances of my own have been alluded to above. Although in all of these cases, as has been stated, some foreign body introduced from without has probably formed the nucleus of the concretion, and although this is the common cause of the formation, Watson⁵ holds that it is possible that the crusts formed in fetid catarrh or ozena, may, when retained for a lengthened period, become consolidated, and subsequently encrusted with the carbonates and phosphates of lime; but he admits that such instances must be rare. Two cases which he records seem to bear out this view.

Nasal calculi may be formed in any of the various passages of the nose; they may even originate in the frontal or maxillary sinuses, and pass thence into the nasal canal, or be formed beneath the pituitary membrane, lying imbedded in the tissues; as a rule, however, they are formed in, and will be found lying in, the inferior meatus of the affected cavity, and their exact position will be determined by the method and direction of their introduction. The reason of their formation is not so clear. Gräfe argues in favor of a gouty dyscrasia, as favoring their production. Durham, with more probability, holds that chronic inflammation of the nasal fossa and lachrymal gland, may give rise to such alterations in the secretions that, a foreign body being present, the deposition of calcareous matter around it can readily be explained. Such deposition is also favored by various anatomical abnormalities, preventing the free exit of secretions. Brown⁶ reports such an example, in which cicatricial closure of the nostril, following smallpox, gave rise to the formation of a calculus weighing three and one-half drachms, which was removed by incising the occluding membrane.

After what has been said, it can readily be understood that nasal calculi may constantly increase in size through the deposition of successive layers, that their contour must depend upon the shape of the cavity in which they are formed, and that they may be either hard and firm, or soft and friable, in their nature. The symptoms to which they give rise have in great measure been detailed in speaking of other causes of nasal obstruc-

¹ Mémoire sur les Calcules nasaux. Arch. Gén. de Méd. 1845.

² Op. cit.

⁴ Archives of Laryngology, vol. i. p. 149.

⁶ Edinburgh Med. Jour., vol. v. p. 50.

³ Vol. i. p. 225.

⁵ Diseases of the Nose.

tion, and of foreign bodies. Pain is a more constant symptom, however; and periodical hemicrania, terminating by the evacuation of a nasal calculus, has more than once been reported.¹ An ichorous or muco-purulent discharge—sometimes stained with blood, and of an offensive character—is never wanting. The very character of this discharge may lead to the mistaken diagnosis of *ozæna*, or fetid catarrh, especially in those cases of calculi in which the mass is encysted beneath the mucous membrane, or located so far posteriorly that it cannot be seen. The peculiar, characteristic click of the probe against it will, in the latter instance, however, render the matter clear. The dilatation of the nostril and the obstruction to respiration will still further complicate the differential diagnosis between calculus and nasal polypus;² and the deformity and accompanying suppuration, that between the same condition and necrosis of the nasal bones; but with care, direct inspection, and thorough probing, the difficulty is easily overcome. The latter is the mistake commonly made; instances are probably familiar to many of us. In a reported case, the calculus was a large one, and was removed by lithotritry in four sittings; it had been mistaken for necrosis of the malar bone. Fraenkel, finally, calls attention to the danger of confounding nasal calculi with calcareous degeneration of the mucous membrane itself. The latter is sometimes found in the nose, especially in the old, but occasionally likewise in the young, in consequence of the ossific diathesis; the membrane covering the turbinated bones may develop, first, fine granular points, and afterwards, plates of calcareous matter. The condition is, however, a rare one. The diagnosis having been made, the removal of the calculus may be at once undertaken by the same methods as were detailed in treating of the removal of foreign bodies from the nasal passages. Granted that it be not too large, nor too firmly imbedded, and that it is accessible, the scoop or forceps will be all-efficient means of removal. In cases where the rhinolite is located beneath the mucous membrane, it will be necessary to incise this down to the stone, to allow of its extraction. Erichsen³ mentions two cases of this kind as occurring in children. When the calculus is too large to permit of extraction by the natural nasal opening, it must of necessity, in order to lessen the danger of laceration of the soft tissues, be crushed up by a strong pair of forceps, or drilled through, and the *débris* washed out by the syringe introduced into the unaffected passage. Cohen recommends that in some instances the point of a knife should be passed under the edge of the calculus, a short distance into the soft parts, and that it should then be pried out, in part, by some blunt instrument. The subsequent treatment, after the removal of the concretion, will be the thorough cleansing of the nasal cavities, and the application of such astringent remedies as may tend to allay inflammation, reduce inflammatory thickening, and heal superficial ulceration. These results—with a subsidence of all subjective and objective symptoms—usually follow very quickly the removal of the offending body.

PARASITES OF THE NASAL CAVITY.

The entrance of living creatures into the nasal cavities is always more or less a matter of chance, and the occurrence a rare one, although the older writers, manifestly wrong, ascribed all cases of *ozæna* attended with severe frontal headache to the presence of insects or their larvæ in that situation. Numerous cases are not wanting, however, in modern times, in which the

¹ Axmann, Arch. Gén. de Méd., Mai, 1829.

² Voltolini narrates the history of such a case. Die Anwendung der Galvano-kaustik, S. 240. Zweite Auflage. 1872.

³ Science and Art of Surgery, vol. ii. p. 390.

diagnosis has been established by ocular demonstration, and the possibility of the occurrence thus shown. Thiedemann¹ has collected proof of the existence within the nose of centipedes (*Scolopendræ*), ear-wigs (*Forficula auricularia*), and the larvæ of the bacon-beetle (*Dermestes lardarius*). The occasional presence of the *Ascaris lumbricoides* has already been alluded to. Urbanek reports such an instance;² Packard, one of the accidental entrance of a centipede into the nostril;³ and Buchanan, a case of the deposition of the ova of the fly in the nasal fossæ.⁴ Leeches have been known to effect an entrance, and to have been dislodged with great difficulty, from these cavities. The larvæ of the dipterous insects, also, are of even more frequent occurrence. Coquerel⁵ reports five cases in which these larvæ, lodged in the frontal sinuses and nasal passages, produced violent symptoms, which in three of the cases were followed by death. In most of them, several hundred larvæ were evacuated by ulceration and necrosis of parts investing the cavities. Coquerel also quotes in his article several analogous cases from authors who had observed similar occurrences in Europe. Cloquet⁶ reports a somewhat similar case. An excellent summary of our present information on the subject is given by Fraenkel. Attracted by the odor emanating from an ozena, flies are found (*Musca vomitoria* and *Musca carnaria*) which deposit their eggs in the vicinity of the nostrils, the young being nourished, when hatched, by the decomposing organic matters. Maggots likewise are occasionally seen in cases of ozena, as in any other purulent and fetid surface or cavity of the human body. According to Von Frantzius, this occurrence is a frequent one in the tropics.⁷ Weber⁸ tells us that in the same locality, especially in Cayenne and Mexico, there is a fly (*Lucilia hominivora*) which sometimes forces its way even into healthy noses and lays its eggs there; the larvæ, measuring one-half inch in length, are developed at the end of fourteen days. Finally, the larvæ of the gad-fly (*Oestrus*) are rarely found in the human nose.

It has been stated that centipedes may remain for years in the frontal sinus. Other parasites make of necessity but a temporary sojourn in the nose. Upon the duration of their stay, then, will depend in great measure the intensity and seriousness of the symptoms. These are never unimportant, and the attendant pain and distress, amounting in many instances to agony, leading to psychical disturbance, delirium, and even death, are graphically described by several authors. All the evidences of general as well as local inflammation, with high fever, are present; the face and fauces become swollen; the nasal discharge becomes fetid and bloody; and ulceration and perforation, especially of the palate, may occur. The prognosis of such cases must always, then, be a guarded one, and frequently unfavorable.

Treatment, if we may judge from the reported instances, is not always attended with success. If the parasites be large and easily reached, they may be extracted with forceps; if they are numerous, careful syringing with carbolyzed solutions, or, as has been recommended, with solutions of corrosive sublimate, with decoctions of bitter herbs or tobacco, or with turpentine, may succeed in dislodging them. The inhalation of chloroform has been highly spoken of as an efficient means of accomplishing the latter result.

¹ Op. cit., S. 11.

² Med. and Surg. Rep., Aug. 3, 1878.

³ Arch. Gén. de Méd., Mai, 1858.

⁴ Virchow's Archiv, Bd. xliii. S. 98.

⁵ Recherches sur la Mouche Anthropage du Mexique. Rec. de Mém. de Méd. etc. Mil., Fév. 1867, p. 158.

⁶ Wiener med. Presse, No. 7, 1878.

⁷ Phila. Med. Times, Oct. 30, 1876.

⁸ Am. Jour. Med. Sci., May, 1828.

TUMORS OF THE NOSE.

EXTERNAL TUMORS.—Tumors located *externally* upon the nasal organ, are of very rare occurrence, and among them the *sebaceous* growth hardly deserves the name of tumor. It is usually small, painless, and of slow growth, and its soft, compressible consistence serves to readily distinguish it from other varieties of neoplasm. Once extirpated, it does not recur. The *fibroid* tumor generally springs from the surface of the fibro-cartilage of the nose lying immediately below the perichondrium, and exhibits the same structure as similar growths in other parts of the body. (Gross.) An important fact in connection with it is its tendency to recurrence after removal. *Lipomatous* tumors, the only other variety of growth met with externally, consist of an accumulation of the subcutaneous adipose tissue, usually associated with marked hypertrophy of the overlying integument, and increased vascularity with distension of the sebaceous crypts. Lipoma occurs in elderly subjects, and is easily recognizable by its lobulated appearance, pendulous character, and soft consistency. The remedy for the disease lies in its excision, care being taken to preserve the nasal cartilages intact.

TUMORS OF THE NASAL PASSAGES.—Tumors of varied pathological nature affect the nasal passages, arising either primarily within them, or involving them secondarily by a process of gradual extension from the neighboring and communicating sinuses and cavities. The commonest form is unquestionably the *mucous* or *gelatinoid polypus*, while the more serious, such as the *fibrous* or *naso-pharyngeal polypus*, the *osseous* or *cartilaginous* growths, as well as the semi-malignant *sarcoma* and malignant *carcinoma*, are fortunately rare. Other forms of tumor are but infrequently seen, and need but passing consideration; they are the *adenoma*, *papilloma*, *neuroma*, and finally *cystic* growths.

General Symptoms.—The earliest symptoms, due to the presence of any tumor within the nasal passage, being in all cases nearly identical—certainly in the incipient stages of its formation—and, as Mackenzie remarks, being neither distinctive with respect to the different classes of growth, nor, in fact, distinguishable subjectively from those of chronic rhinitis, it may be well to consider them here collectively, laying special stress upon those of a later date which in certain forms of neoplasm have a diagnostic significance. Hypersecretion, sensation of fulness, and constant desire to clear the nose and throat, with perhaps frontal headache and some nasal obstruction to respiration—in short, the symptoms of a chronic coryza—are the first to attract the patient's attention, and become so gradually pronounced that the surgeon's attention is rarely called to the affection in this stage. As the tumor develops, however, all the symptoms and attendant discomfort, due mainly to obstruction of one or both nasal passages, are decided. The patient then breathes partially, perhaps wholly, through the open mouth, the senses of taste and smell become blunted, and the voice acquires the characteristic, nasal intonation. The direction of the growth of the tumor determines the development of further conditions: if it be backwards, it presses upon the pharyngeal orifice of the Eustachian tube, and impairment of hearing follows; if upwards and forwards, it presses upon the outlet of the nasal duct, and lachrymal abscess, epiphora, or mucocoele of the lachrymal sac are not unusual results; if backwards and downwards, it encroaches upon the soft palate, and limits its movements in deglutition; and finally, by blocking up the outlet of the antrum of Highmore, it may induce the development there of a cystic or other growth. Mucous polypi being often pedunculated, give rise

to an uneasy sensation by moving backwards and forwards in the respiratory current through the nose; and, being likewise hygroscopic, or ready absorbents of moisture, their size, and the consequent degree of occlusion which they cause, vary greatly with changing atmospheric conditions. Even when they are multiple, or their size excessive, they rarely cause any distortion of the neighboring parts, the soft growth or growths adapting themselves to the contour of the surrounding nasal walls. The fibroid growth, on the contrary, displaces all in its growth, pushes aside the septum, absorbs bone or separates connecting sutures, and penetrates and develops in all directions, producing the characteristic deformity known as "frog face" when it invades and displaces the antrum on either side; in the latter case the attendant nasal discharge, usually of a thin, watery nature only, becomes purulent and even fetid, and frequent attacks of epistaxis occur.

Pain is a frequent symptom in this class of growth likewise, as well as in the osseous, cartilaginous, and malignant varieties, and may be excessive. Not only does characteristic deformity of the nose attend all of these forms, but displacement of the eyes, strabismus, inability to close the lids, chemosis, conjunctivitis, distortions of the internal parts of the mouth, and the like, are no unusual results. With sarcoma and carcinoma must be added, softening and ulceration of the tumor, with their sequelæ, fungoid granulations, hemorrhages and fetid discharges. Constitutional cachexia and infiltration of the neighboring lymphatics, are absent in sarcoma, present in carcinoma; with both there is excessive pain, and a tendency to penetrate into the cavity of the orbit or brain, or destroy in their onward march the tissues and soft parts of the nose and cheeks, and appear externally upon the face as a fungoid, bleeding mass.

One complication or result of the nasal obstruction caused by polypi, or even by the hypertrophy of the tissue over the turbinated bones, in certain instances, is of sufficient interest to demand special mention. I allude to their direct influence in the causation of *bronchial asthma*. Thudichum¹ asserts that there is no more common complication of nasal diseases, particularly polypus; and since the first observation was put upon record by Voltolini,² numerous cases have been detailed, and the subject carefully studied by several authors—Porter,³ Fraenkel,⁴ Haensisch,⁵ Daly,⁶ Hartmann, Spenser, Rumbold, Todd, Mullhall, and Schäffer. Joal⁷ details eleven cases of his own, in all of which the asthmatic attacks immediately disappeared after the removal of the polypus, though in some instances only to return as soon as the nasal respiration became affected by the recurrence of the growth. All of the patients were of marked gouty constitution. He shows us that mucous polypi, which may be innocent in some individuals, in others play a part—occasional, without doubt, but powerful—in the causation of nervous respiratory troubles. All of the above observations show then, beyond question, that not only may the reflected irritation from nasal obstruction be the exciting cause of asthma, but that, if the cause be prolonged, local bronchial lesions may be the result (Thudichum); and that to cure the condition, the removal of the cause of the reflex irritation is requisite, and usually promptly succeeds. The irritation of the pneumogastric nerve, which induces the spasmodic contraction of the bronchial muscles, and thus approximates the cartilaginous rings of the bronchi (Bert, Traube), is probably excited by reflected impressions received through the medium of the fifth

¹ Lancet, April 17, 1880.

² Galvanokaustik, S. 246, 312. 1871.

³ Med. Record, Oct. 11, 1879, and Archives of Laryngology, vol. iii. No. 2.

⁴ Berlin klin. Wochenschr., Nos. 16, 17. 1881; and Ziemssen's Cyclopædia, vol. iv. p. 107.

⁵ Berlin klin. Wochenschr., S. 503. 1874.

⁶ Archives of Laryngology, vol. ii. 1880.

⁷ Archives Gén. de Médecine, tome i. 1882.

nerve. (Other less tenable theories, it may be here stated, are advanced.) It has been objected that this implies peripheral irritation producing central disturbance, thence reflected to the nerve of supply and to the part affected—that is, an impression conveyed from the origin of the fifth nerve to the origin of the pneumogastric. But Porter remarks, that even were this true it would not disprove the theory; and he adds, that there is a more direct line of communication. The pneumogastric, though in its origin a sensory nerve, receives motor filaments from the seventh, or portio dura (to auricular branch), from the spinal accessory (to ganglion of the root), from the hypoglossal (to ganglion of the trunk), and from the first and second cervical nerves. As the contiguity of the origin of the cranial nerves is now demonstrated, it is reasonable to suppose that impressions may be conveyed from the origin of the fifth nerve directly to the origin of any of these, and thence by a continuous motor-tract to the pneumogastric.

The original and direct cause of the irritation does not arise in the polypus itself, in cases where it is present; this is impossible, as the ordinary gelatinous polypi are destitute of nerves, and can therefore, as J. N. Mackenzie justly observes,¹ only awaken reflex phenomena in an indirect or mechanical manner. They do so then only when they spring from, or, much more commonly, by their position, form, etc., are brought in contact with, the erectile tissue covering the inferior turbinated bones, and especially their posterior extremities. By acting here as a mechanical irritant, they cause engorgement of the mucous membrane and erectile cells, and thereby excite the chain of reflex action described above.

Aside from asthma, *reflex cough* has recently been* recognized as a symptom of a number of pathological conditions, affecting especially the erectile tissue covering the posterior extremities of the turbinated bones, but J. N. Mackenzie² has called attention to the direct influence of nasal polypi in its production. The cough is only present, he tells us, when the growths are brought in contact with the erectile area alluded to above, and thus excite reflex action and produce explosive cough. The probability of cough excitation will mainly depend therefore, other things being equal, upon the position of the growth. In regard to the mechanism of the reflex, two explanations are given: either the assumption of the correlation of the nasal erectile area and the inter-arytenoid space (laryngeal cough centre), by virtue of which irritation and vascular engorgement of the former may lead to hyperæmia of the latter through the medium of the vaso-dilator nerves, through the superior cervical ganglion, and to the consequent production of a laryngeal cough; or the direct transmission of the irritation through the sphenopalatine nerves to the medulla, and its immediate reflection outwards to the muscles concerned in the expiratory act.³

As has been said, the removal of the polypus, or other occluding cause, from the nasal passage, has, in the majority of instances reported, been effectual in curing the asthmatic complications and the cough, without recourse being had to further measures. It is advisable that this should be done at an early date, to prevent any possible change in the texture of the lung tissue, or the occurrence of chronic hyperæmia.

General Diagnosis.—By means of a skilful anterior and posterior rhinoscopic examination, the observer is almost always in a position not only to diagnose accurately the fact of the presence of a growth within the nasal passage, but likewise to determine its location, extent, and not unfrequently the nature of its attachment, and, from its appearances alone, its pathological

¹ Medical Record, May 3, 1884.

³ See section on Nasal Cough, p. 830.

² Loc. cit.

nature; exceptions exist, it is true, especially in the case of multiple growths, and those of great size, which involve neighboring cavities; here much care and repeated examinations are necessary to establish a correct diagnosis. Certain facts, if borne in mind, will serve to elucidate the problem, and these are so clearly stated in the valuable essay of Mackenzie,¹ that I here take the liberty of presenting them in part, in a condensed form, and with certain additions.

The softness, elasticity, mobility, and pale translucent appearance of mucous polypi contrast strongly with the hardness, opacity, fixedness, and deeper red color of other tumors. Fibroid, sarcomatous and malignant formations usually bleed, even when gently touched. Cartilaginous and osseous growths are heavy and dense, and offer such a sense of resistance to the probe that their real nature is at once apparent. The probe will also enable the surgeon to distinguish the chronic thickening of the mucous membrane covering the inferior turbinated bone, met with in hypertrophic nasal catarrh, from polypus. In the former case, the absence of a pedicle, the consistence, and the gradual blending of the outgrowth with the structures around the base, assist the differential diagnosis. The possibility of the existence of a deflected septum, and of the blood tumors and abscess of the latter, elsewhere described, must not be forgotten, as they are perhaps calculated to deceive the inexperienced observer. Mucous distension of the ethmoidal cells is mentioned likewise by Watson² as a possible source of diagnostic error. Fibromata may be distinguished from mucous polypi, not only by the characteristics of both, mentioned above, but also by their lack of the hygro-metric quality. They are generally harder, slower in growth, and more distinctly pedunculated than sarcomatous and cancerous growths. The absence of cachexia, and of involvement of the lymphatic glands, serves also to differentiate them from the last. Cartilaginous growths are never pedunculated, seldom ulcerated, and present more smoothness of surface, with symmetrical, globular outline, than other forms of tumor. The touch alone is sufficient to establish the nature of an osseous tumor; while sarcoma can only be confounded with carcinoma. Mackenzie says that in the nose it is much more frequent than the latter, and can generally be recognized by its occurring at an earlier age, and by its displaying a much milder type of malignancy. Finally, in regard to cancer—for the other growths alluded to as occurring in the nose, but not here mentioned, occur so very rarely that, practically, they are of but little importance in relation to differential diagnosis—there is, unfortunately, no room for doubt when the disease has once commenced to progress; its rapid growth and equally rapid ulceration, and the widespread destruction which it causes, tell the true story of the distinctive malignancy of this form of neoplasm.

MUCOUS POLYPUS OR MYXOMA.—The gelatinoid or mucous polypus is by far the most frequent variety of tumor encountered in the nasal passages, occurring more frequently than all of the other forms combined. Views as to its causation vary. An enlargement of the acinous glands, with attendant hypertrophy of the submucous tissues and covering mucous membrane, with serous infiltration, so that the membrane is pushed or drawn out by the gradual increase of the growth into a narrow pedicle, and this as the result of repeated inflammatory attacks, or chronic nasal catarrh, is probably the common cause; in other words, it may be regarded as a localized hypertrophy. An adenomatous variety is not unusual. Gruner and Pott attribute

¹ Lectures on Diseases of the Nose. *Lancet*, July 28, Aug. 25, Nov. 10, 1877.

² Diseases of the Nose, p. 72. London, 1875.

the origin of mucous polypi to such influences as heredity, struma, syphilis, miasma, suppressed menstruation, and the like (Mackenzie), while instances exist in which the local irritation of a foreign body has determined their development. The polypus, of a dingy, bluish-white color, with a smooth, shining, elastic surface covered by ciliated epithelium, devoid of sensibility and breaking easily under pressure, almost bloodless, of variable size and configuration¹—the latter being determined by the gravitation of the contents of the polypus downwards, and by the shape of the nasal fossæ—is single or multiple, and attached, as a rule, to the superior turbinated bone, more rarely to the middle, and only very occasionally to the septum;² it may spring from the roof of the nose, or may extend into that organ from the frontal or ethmoidal cells, though this occurs but rarely. A single polypus may even be attached at several points to the surrounding nasal parts,³ but such roots are always to be regarded as the result, in the first instance, of pressure and friction, with subsequent ulceration and cicatricial adhesion, and not as true points of origin. Occasionally polypi contain fibro-cartilaginous concretions, or have small osseous formations upon their surface. Polypi are more frequent in adults than in children, and are found rather in males than in females. Once carefully removed, close to their attachment, the prognosis as regards their re-formation is favorable. Mackenzie⁴ says that only one in seven recurs, but he calls attention also to the important fact that, as in the case of recurrent growths, there is always a possibility of malignancy, proportionate to the rapidity with which they increase in size. The prognosis must be a guarded one, until lapse of time has established facts in respect to the question of recurrence or non-recurrence.

Treatment.—The surgeon called upon to undertake the removal of nasal polypi has a wide choice as to means. The inventive ingenuity of the profession has for years expended itself upon this subject, if I may judge from its literature. But here, as in other like conditions, the simplest surgical means consistent with the indications have proved the best. *The application of various drugs* has been, and is to-day, extolled by observers whose ranks from time to time receive additions. Unquestionably, a gelatinoid polypus is occasionally amenable to local remedies, but cures thus obtained are not the rule; these means may be summarized as follows: Primus,⁵ the repeated local application of saffronized tincture of opium (Pr. Phar.); Bryant,⁶ that of iodine; Mackenzie,⁷ perchloride of iron, mixed with sufficient water to form a thick paste (also Reeder); other authorities, oxysulphate of antimony with sugar, gallic acid, tannin alone or in combination with burnt alum, borax, sugar, or camphor (Cohen), alcohol, strong astringent solutions, sulphate or chloride of zinc (Erichsen), or copper, and the like, lime-water, calomel, bichromate of potassium, nitrate of silver (Nélaton), and pulverized blood-root (Gross) as a snuff.

Injections.—Reynolds⁸ and others recommend the injection of the polypus by means of a hypodermic syringe with various solutions; among the remedies used, carbolic acid, glacial acetic acid, Lugol's solution, and tincture of the chloride of iron (Reeder), occupy a prominent place.

Evulsion is probably the method most widely employed, and, though condemned in unmeasured terms by Voltolini, Michel, and Zaufal, when forceps are used, in good surgical hands, they can be productive of no harm,

¹ Billroth, Ueber den Bau der Schleimpolypen. Berlin, 1855.

² Davies Colley, Brit. Med. Jour., June 30, 1877, p. 810.

³ Meckel, Path. Anat., pp. 304, 311, 313.

⁴ Lectures on Diseases of the Nose. Lancet, July 28, Aug. 25, Nov. 10, 1877.

⁵ Am. Jour. Med. Sci., vol. ii. p. 219.

⁶ Lancet, Feb. 23 and Aug. 24, 1867.

⁷ Lancet, July 28, 1877.

⁸ Med. Record, Oct. 1, 1881.

not even excessive hemorrhage. In simplicity and certainty this method surpasses all others, and though it is more painful, it is much more rapid. The operation is performed either with forceps, or with some one of the various forms of wire *écraseur*. The *forceps* should be a lightly made instrument, either straight or with a slight curve in its shank, so that the handles will not obstruct the operator's view, and with a firm, close bite, and well-serrated blades. The nostril having been well dilated by means of a nasal speculum—Fraenkel's or any of the ordinary wire specula will answer the purpose—and the polypus, the precise location and attachments of which should have been previously well studied, brought into view, its pedicle or base may be seized, well twisted, and the growth then torn out. When the growth is located far back in the nasal passage, so that it cannot be seen during the introduction of the forceps, the operator must rely in great measure upon his *tactus eruditus*, in his efforts to seize it. Occasionally, a tumor thus located can be pushed forwards into view by the finger carried up behind the soft palate. When the growth is very large and has numerous attachments, it is ordinarily extracted piecemeal. Stoker has invented a forceps for carrying out evulsion very perfectly. A fine forceps is fixed to a wooden handle at an angle of 45° . The growth being seized at its base, the horizontal portion of the instrument is retracted from the groove in which it lies, and is then rotated, while the handle remains firm. The forceps on the pattern of the midwifery forceps occasionally answers a better purpose than the above instruments; one blade at a time is adjusted in position, then both are locked, and a firm hold on the tumor is thus obtained. (Schreger, Richter.) Dzondi recommends that the growth be drawn forwards with one pair of forceps to put its pedicle upon the stretch, and that the latter should then be caught by a second forceps, and crushed through, as close as possible to its attachment. It is possible that, when the exceedingly friable nature of the gelatinoid polypus, and the readiness with which it tears into bits in the grasp of the forceps, render its extirpation difficult, this procedure may be of benefit. A polypus frequently breaks up, and a firm hold upon it, and thorough eradication, root and branch, are impossible, with one introduction of the forceps; in such cases a repetition of the procedure should be undertaken, the blood being syringed away, and frequent halts being made for visual inspection, until the operator is assured that the result for which his operation was undertaken, viz., entire extirpation of the polypus or of the polypi, has been thoroughly accomplished.

The tendency to the reproduction of these tumors may, to a certain extent, be controlled by the topical use of astringents and even caustics; but upon each reappearance, a repetition of the above procedures, or some one of them, becomes necessary. A case is cited, in the literature of this subject, of an individual who was obliged to submit to an operation of this kind every month for forty consecutive years. In cases where this tendency to reproduction of the polypus exists to an excessive degree, Gross recommends that half or even more of the implicated turbinated bone shall be removed by the forceps, in addition to the polypus, following in this advice the example of Ferguson and Pirogoff.¹ Mackenzie even asserts that there are some polypi which, from their anatomical situation, cannot be removed unless a portion of the turbinated bone be previously taken away, or unless the bone be removed with the growth; and to do this he recommends that an instrument be used which consists of a fine hollow forceps, having toothed edges on one side and smooth edges on the other, while between the two a sharp cutting blade can be rammed down.

¹ Klin. Chir., Heft iii. S. 74. Leipzig, 1854.

Evulsion by means of the wire-snare is preferred to other methods by many operators, who, through practice, have become expeditious and skilful in applying the wire over the polypus, and pressing it up well towards its attachment—sometimes a small, blunt fork, passed into the nostril, assists this step of the procedure—and it is claimed by many that the method is less painful and more thorough, and that there is less hemorrhage and danger of laceration, than if the forceps is used. (Durham.) Among the many different forms of wire-snare, or *écraseur*, that of Hilton, modified by Blake, and the snare of Jarvis, are perhaps the best. The wire is passed about the growth, and as near as possible about its pedicle, and then drawn home, by sliding back with the fingers the cross-piece on the bar of the instrument to which the ends of the wire are attached. Thus securely fastened about the tumor, this is torn away by withdrawing the instrument from the nose. This procedure answers for growths situated anteriorly, and easily accessible; but when they are located far back in the nasal passage, and, perhaps, hanging into the cavity of the pharynx, they must be encircled by a loop of wire passed through the nose into the mouth, the tumor being controlled by a strong thread previously passed through it, if possible, and coming out of the mouth. The loop of wire having reached into the pharynx, or around the velum into the mouth, is guided over the growth by the fingers of the operator, passed behind the soft palate. A double canula is now sometimes passed over the ends of the wire, through the nose, and the latter is then drawn home so as to strangulate and thus cut away the growth. I can see no object in prolonging this process of strangulation through several days, until the growth drops off from its attachment, as is sometimes done. Bellocq's canula is sometimes of assistance in passing the wire about the polypus in the above procedure, as well as the tying forwards of the soft palate, as recommended by Wales, by means of tapes or elastic cords passed through the nose, brought out through the mouth, and fastened over the upper lip. Much space is thus gained in the pharynx, in which to carry out the requisite manipulations. Much depends, however, in any instance, upon the skill and ingenuity of the operator, and the particular methods of attaining success must be suited to the indications presented by each individual case. Gross succeeded in one instance in breaking off a polypus hanging down into the fauces, by simply introducing the index finger into the mouth, and carrying it around the soft palate; and it is true that polypi may occasionally be removed by the fingers alone—one being thrust into and through the posterior naris, the other through the anterior, and the growth, grasped between them, being pushed backwards and forwards until its attachment is torn through. (Morand and Sabatier.) McRuer, reviving the procedure recommended by Hippocrates, passed a piece of catgut through the affected nostril, and, after it had reached into the pharynx, tied a piece of sponge to it; the latter was then forcibly drawn through the nose, tearing away in its course the adventitious growths. This method, or a modification of it, has recently been advocated also by Voltolini.¹ In any case, care must be taken to secure the tumor previous to its division from its attachment, to prevent its falling upon, or into, the larynx. Knives and scissors are rarely used to excise polypi, unless these be situated in the anterior nares, and thus easily accessible. The toothed scissors of Richardson would here play a useful part. Anæsthetics may be required in any of the above operations, but are a decided disadvantage, and their use should be avoided if possible, and the intelligent co-operation of the patient thus secured. Tamponing the posterior nares, on account of hemorrhage, will be rarely requisite.

The *galvano-cautery*, which was first used in the removal of polypi by

¹ Monatsschr. für Ohrenheilk., No. 1. 1882.

Middelдорpf, and subsequently warmly advocated by Voltolini, is applied either by means of the wire loop, or with various electrodes. In the former case, a platinum wire is passed about the growth, as above described, drawn home through a double tube introduced through the nose, and attached to a suitable handle, which is in connection with a powerful galvanic battery. As soon as constriction of the mass is effected, the connection is closed, and the growth burnt through. The disadvantage of this operation, aside from the pain, is, that the wire can rarely be accurately adjusted to the pedicle of the tumor, and that, as no traction upon the roots is made, the growth is not thoroughly extirpated. Thudichum¹ is at present the warmest advocate of this instrument, but even in one of his own cases the operation had to be repeated some fifty-five times.

Enlargement of the Outlets of the Nasal Cavity.—Such an operation may, in rare instances, be requisite when the tumor is of such a size, or so placed, as not to be easily reached and extracted through the natural openings. The simplest method consists in the dilatation of the nostril by laminaria tents, as proposed by Thudichum, or by the blades of strong forceps. Should, however, more room be necessary, the choice lies between the method of Dieffenbach,² by cutting the wing of the nostril to the edge of the nasal bone—or, if both alæ are freed, the septum is also divided, and the nose turned upwards upon the face—or that of Maune (modified by Maisonneuve by leaving the uvula intact, and called the “buttonhole” opening), by incising the soft palate throughout its whole extent in the median line. The latter method is specially applicable to those cases in which the growth is located well back in the nasal passage; the polypus is encircled by the wire loop passed through the opening thus made, and is removed by crushing.

After any of the above operations, careful cleanliness of the affected nasal passage must be insisted upon; and Durham asserts that, in some cases, the insufflation of tannin or other astringent powder is of great service, either in retarding the re-development of the growth, or in aiding the destruction of such portions as may have had their vitality impaired by the operation.

FIBROUS POLYPUS.—This may occur at any period of life. Gross has seen it in children under fourteen years of age, as well as in adults and in old persons; but, originating in the nasal cavity, such a growth is very rare. It may grow from any part of the walls of the nasal fossæ, springing from the aponeurotic covering of the bones, or from the periosteum, with which, as well as with the subjacent bone, it is closely connected; but it is ordinarily attached by a broad base to the superior turbinated bone, or to the roof of the nose, and so far back that it is not readily seen in an anterior examination of the nasal passage. Rogers³ removed such a polypus from the vomer. Other cases are reported where the growths sprang from the floor of the nasal fossæ, and even from the external lateral walls of the nose; furthermore, they may originate in the antrum, and extend thence into the nose. The exact point of origin is often very difficult to determine, owing to the tendency of the growth to acquire secondary attachments.

Its substance is made up of hard, white fibres, or connective tissue, interspersed richly with bloodvessels; occasionally, round and fusiform cells are present, but rarely in large numbers; its color is a dark red or purple. The surface of the tumor, when denuded of its epithelium, bleeds readily on

¹ On Polypus of the Nose and Ozæna. London, 1869.

² Surgical Observations on the Restoration of the Nose and the Removal of Polypi. London, 1833.

³ N. Y. Jour. Med., vol. i. p. 323. 1851.

slight irritation, and is not infrequently ulcerated at several points. Calcareous deposits¹ sometimes occur within it, and cartilaginous and osseous degenerations² of the growth are not unknown. Allowed to pursue its course, unrelieved by operation, it often attains an enormous size; and displaces, distorts, and destroys all parts in its immediate neighborhood, giving rise to the most hideous deformity, and to imminent danger from compression of the brain or other cerebral complication.

A tumor possessing the same general characteristics, and of the same nature, springs usually from the basilar process of the occipital bone and the adjacent part of the body of the sphenoid, and is more common than the first-mentioned form. It is distinguished by its origin, rapid growth, and serious results, and is known as the *naso-pharyngeal polypus*.

Naso-pharyngeal polypus,³ aside from a point of origin as above, may arise from the pterygo-maxillary fossa; as it enlarges it may extend thence outwards into the zygomatic and temporal fossæ, and inwards through the sphenopalatine foramen into the pharynx; but Sands⁴ correctly remarks that tumors thus arising form a special group, and should be distinguished both anatomically and clinically from that which has been mentioned above, which embraces the fibrous growths most often met with in this neighborhood, and to which the name of *naso-pharyngeal polypus* has been correctly applied. The latter, according to some writers, always springs from the site first given above, but cases exist where it has been found to have had its point of attachment to the following parts: the antrum, the upper part of the pterygoid fossa, the internal pterygoid plate, the greater wing of the sphenoid, the apex of the petrous portion of the temporal bone, and lastly, the edges of the posterior nares; occasionally it springs apparently from the upper part of the spinal column. (Michaux, Robert, and others.) Whatever its site, the tumor extends, in its gradual growth, downwards, or forwards, until it blocks up the entire upper and middle pharynx, involves both the mouth and nasal passages, and, after having displaced or caused the absorption, perforation, or destruction, of all parts opposed to its irresistible onward march, appears at the anterior nares with great distortion of the external nose, or in the middle pharynx with protrusion forwards of the soft palate. Massé records instances in which *naso-pharyngeal polypi* penetrated the pterygo-maxillary fissure, and passed through the pterygoidean space, between the muscles, towards the face. Extensions are not infrequently found into the antrum, and the frontal and sphenoidal sinuses, and prolongations reach through the sphenomaxillary fissure into the orbit, and displace the eyeball.⁵ Robert asserts that these growths spring from the foramen lacerum anterius. The polypi are usually pedunculated, and not infrequently form firm attachments to the various points upon which they press, thus rendering their exact point of origin doubtful. Their growth is rapid, and extirpation is apt to be followed by recurrence. Spontaneous cure by sloughing rarely occurs. (Johnson, Birkett, Bonnet, Vincent, and others.) A marked tendency to undergo sarcomatous degeneration is exhibited,⁶ and a special tendency to penetrate the cavity of the orbit, or that of the cranium, although, according to some authorities, the latter occur-

¹ Bourdilliat, Fibrome calcifié. *Gaz. Méd.*, 1868: and H. Cloquet, *op. cit.*, p. 688.

² Virchow, *Die krankhaften Geschwülste*, Bd. i. S. 185.

³ Consult Giralès; Massé, *Des polypes naso-pharyngiens*. Paris, 1864; D'Ornellas, *Anat. path. et traitement des polypes fibreux de la base du crâne*, etc. Paris, 1854; Brevet, *Des polypes naso-pharyngiens*. Paris, 1855.

⁴ On *Naso-pharyngeal Polypi*. *Archives of Scientific and Pract. Med.*, No. 6, June, 1873. (Reprint.)

⁵ Spence, *Edinburgh Med. Jour.*, vol. ix. p. 996.

⁶ Weber, Billroth und Pitha's *Handbuch*, Bd. iii. Abth. i. S. 207.

rence is a rare one. Gross¹ states that these tumors are by far most common in young subjects, between the fifteenth and twenty-fifth years, and that neither his own experience nor recorded instances present any example in the female. To this latter statement, I must except that Marjolin² reports the case of a girl, aged two, who died from the extension of such a growth, and Lincoln, eight additional cases in females;³ and one instance at least is known of the growth occurring in a patient of fifty-five. Winter⁴ reports an instance in a fœtus of seven months. Sands remarks that the discovery of a polypoid growth at either extreme of age would be presumptive evidence of its malignancy. Naso-pharyngeal polypi are much more frequent in males than in females (in 58 cases, 48 were males, 8 females, 2 not stated), and the precise causes of their origin are involved in complete obscurity.

The main points in the *diagnosis* of these growths have elsewhere been touched upon. It will be sufficient to add here that malignant tumors of similar origin, intra-nasal fibrous polypi, and even syphilitic nodes and serofulous abscesses, may, when located in the pharynx, simulate true naso-pharyngeal tumors. Cruveilhier reports a case in which a portion of the dura mater, thickened, exhibiting a fungous appearance, and containing parts of the arachnoid and pia mater, with cerebral substance and pus, formed a hernia through the cribriform plate of the ethmoid bone; and Virchow a like one, in which the tumor penetrated the palate and protruded through the mouth. Such cases, though rare, may complicate the diagnosis. An important point to bear in mind is, that the region in which true naso-pharyngeal polypi can originate is one of narrow limits, corresponding with the margins of the posterior nares and the summit of the pharynx. (Sands.)

Treatment.—For the removal of the smaller fibrous polypi, any of the methods detailed when speaking of the treatment of the gelatinoid variety, are applicable; but when the growth is large, and has invaded or displaced, not alone the nasal cavities, but likewise those in connection with them, more extensive operative procedures become necessary. In certain rare instances, naso-pharyngeal polypi have spontaneously sloughed away, or have separated from their attachments and been expelled. Such cases are reported by Johnson,⁵ Birkett,⁶ Saviard,⁷ Bonnet, Vimont,⁸ and others.⁹

Operative interference, by complete and radical extirpation of the growth, with its underlying parts and all extensions, is the only treatment upon which absolute reliance can be placed, certainly in extreme cases. It may here be briefly stated that the judgment of modern surgery is against recourse to the use of avulsion, ligature, and caustics, as means of eradicating these growths; the reasons, based on experience, are apparent to those familiar with the literature of the subject. The first method (*avulsion*) is advocated by Schuh,¹⁰ who has had one successful case. Dupuytren, attempting the same procedure, lost his patient from hemorrhage. Cooper Forster¹¹ has seen it attended by fracture of the cribriform plate of the frontal bone, and death from general arachnitis and limited sloughing of the brain. Guérin's¹² plan seems no better, although it was attended by success in one case. The tumor was steadied by the left fore finger introduced behind the soft palate, and then torn from its base by means of a bone scraper introduced through the nose. Forster

¹ System of Surgery, vol. ii. p. 372.

² Arch. of Laryngology, vol. iv. No. iv.

³ Brit. Med. Jour., vol. i. p. 61. 1858.

⁴ Recueil d'obs. chir., p. 112. Paris, 1784.

⁵ Quoted by Brevet, op. cit., p. 16. Paris, 1855.

⁶ Massé, D'Ornellas, Durham.

⁷ Trans. Clin. Soc. Lond., vol. iv. 1871.

⁸ Gaz. des Hôp., 25 Mai, 1861.

⁹ Günther, Operationen am Halse, S. 311.

¹⁰ Brit. Med. Jour., vol. i. p. 119. 1858.

¹¹ Wiener med. Wochenschr., S. 99. 1865.

¹² Gazette des Hôp., p. 144. 1865.

in one case tore the tumor from its attachments by the fingers alone. The *ligature* has also, it is true, been successfully employed in a few cases. It is, however, impracticable when the tumor is large, has numerous attachments, or is wide spread. The method of applying the ligature has elsewhere been described.¹ Michaux² reports an apparently successful case of its use. Gunther³ lost a patient by the tumor having fallen, after separation from its attachment, upon the laryngeal aperture, thus causing suffocation. Other deaths are reported from pyæmia—a result to be anticipated from the presence of the large, sloughing mass in the pharynx—and from laryngeal complications. But passing mention need be made, and that in condemnation, in the present state of our surgical knowledge, of the chain-saw (Deroubaix), and of the *écraseur* (Chassaignac), although Durham and Bryant report successful cases of the use of the latter. *Caustics*, such as the actual cautery, caustic potassa, chloride of zinc, and the like, are, in the great majority of cases, not only absolutely inapplicable, but seem in all instances to stimulate increased growth. The increase of the tumor thus defies the energetic attempts made for its destruction. The *galvano-caustic ligature*, first employed by Middeldorpf in 1853, has a number of successful cases to be placed to its credit—notably, three reported by Lincoln⁴—but is open to many of the objections already alluded to. As in Dr. Lincoln's cases, it may be radical and complete in its work of extirpation, but on the other hand it often fails, and quick reproduction from the undestroyed base of the tumor is the result. The size, location, method of attachment, prolongations, and involvement of neighboring parts by the tumor, must determine the indications for its use over more severe surgical procedures. It is certainly less open to objection than the means thus far alluded to. Electrolysis has answered its destructive purpose in a few reported cases,⁵ and though the process is slow, may prove satisfactory in the removal of small tumors, especially those of an erectile nature. That it is a means of anything like general application, is out of the question.⁶ Nothing in the above remarks is to be construed as against the use of the actual or galvano-cautery, as a means of destruction of the base of a growth after the more radical procedures for its extirpation that are now to be considered; nor as a method of reaching parts inaccessible to the knife, even after the cavity of the pharynx has been opened from without. In both such instances they serve a useful purpose, and indeed are indicated, to destroy all possible remains of the tumor.

The methods of operating for the purpose of first rendering these tumors directly accessible, and, this being accomplished, of extirpating them, remain now to be considered. I shall merely allude to the methods of procedure, which are many and varied, and to their originators. A special description of the operative steps requisite in each method, is not necessary here, and is impossible in the space allotted for this article. The subject is treated of in the majority of works on general surgery, and in other portions of this work.⁷ In preparing the following summary, I have received much assistance from the valuable *brochure* of Sands already quoted, and to it I can confidently refer the reader for a succinct description of the operative procedures, illustrated with wood-cuts showing the lines of the various incisions through either mouth or face, by means of which direct access is gained to the pharynx.

¹ See section on nasal polypi.

² Schmidt's Jahrbucher, Bd. cxxxiv. S. 311.

³ Operationen am Halse, S. 313.

⁴ This paper contains a record of 74 operations for naso-pharyngeal polypi in 58 patients, tabulated with the result of the operative treatment. The series embraces all cases published from 1867 to date of publication. Archives of Laryngotomy, vol. iv. No. iv. 1883.

⁵ Nélaton, Med. Times and Gaz., March 16, 1867.

⁶ See Althaus on the Electrolytic Treatment of Tumors.

⁷ See Vol. III., pp. 569–573, and pp. 935, 936, *infra*.

I. *Operations through the Mouth*.—Of ancient origin, this method was revived by Maune, and still more recently by Nélaton.¹ It consists in exposing the polypus, either through an incision in the median line of the soft palate, dividing it completely or extending only to the base of the uvula, or by combining this incision with exsection of part or all of the hard palate. Massé² quotes twenty-six cases, in thirteen of which the results were favorable.

II. *Operations through the Face*.—This method embraces resections of some one or more of the bones of the face. The resection may be temporary or permanent; in the former case, the excised portion of the bone is replaced, after the extirpation of the tumor. This operation receives the specific name of "osteoplastic resection." The facial methods of operating, then, embrace 1st, Excision, partial or total, of the upper jaw; and 2d, Various osteo-plastic operations.

Total excision of the upper jaw was first advised for this purpose by Whateley, and practised, unsuccessfully, by Syme³ in 1832, by Flaubert in 1840,⁴ by Verneuil⁵ in 1860, and since that date by Michaux and many other operators.⁶

Partial excision of the upper jaw, for the removal of naso-pharyngeal polypus, was first performed by Maisonneuve⁷ in 1860, and since that date has been repeated by many operators. It is the operation commonly selected.

Osteo-plastic Operations.—Those best known are five in number, viz., the two methods devised by Langenbeck,⁸ and those of Huguier,⁹ Roux,¹⁰ and Cheever.¹¹ Full details as to the necessary procedures will be found in the monograph of Sands. This surgeon sums up the respective merits and relative value of all of these preliminary operations for the extirpation of naso-pharyngeal polypi, as follows (I take the liberty of condensing his remarks slightly):—

Operations through the mouth have the advantage of avoiding mutilation of the face, the features being left untouched. Nor can it be denied that such operations have sometimes been done with gratifying success. If the pedicle be narrow, and the situation of attachment central, it may be dealt with thoroughly after simple section of the soft palate, and, its attachment having been destroyed, the wound in the palate may be closed at once by sutures, with every probability of securing primary union. But it must be confessed that the operation can rarely be conducted in the manner described, and the published cases prove that it has generally been found impracticable to destroy the pedicle so completely as to warrant the immediate closure of the wound in the soft palate. Accordingly, it is the practice of many surgeons to leave the wound open until the pedicle has been removed by some subsequent procedure, and afterwards to restore the palate by staphyloraphy. These facts alone prove that the method now under consideration does not afford the space requisite for the removal of a tumor having extensive attachments, and that in this respect it must be rejected as defective; moreover, it is by no means easy to destroy the pedicle afterwards, and for similar reasons. The actual cautery and various caustic applications have been employed for this purpose. In many instances, the pedicle has continued to increase in size, in spite of treatment, and the surgeon has been finally driven to the alternative of excision of the jaw to gain the desired end. Fatal results have more frequently followed operations through the mouth than those of apparently greater magnitude, so that the former operations cannot, as a rule, be

¹ Bull. de la Soc. de Chir., tome i. p. 159.

² Edinburgh Med. Jour., vol. xxxviii. p. 322.

³ Mém. de la Soc. de Chir. Paris, 1860.

⁴ Gaz. des Hôp. 1860.

⁵ Deutsch. Klinik, S. 281. 1861; and Schmidt's Jahrb. Bd. cxii. S. 195.

⁶ Bull. de l'Acad. de Méd., p. 783. 1860; and Gaz. des Hôp., p. 337. 1861.

⁷ Gaz. des Hôp., p. 354. 1861.

⁸ Med. and Surg. Reports of the Boston City Hospital, p. 156. 1870.

⁹ Op. cit.

¹⁰ Schmidt's Jahrbucher, Bd. xxx. S. 63.

¹¹ See Massé (op. cit.), for details.

recommended either for their safety or certainty—they avoid disfigurement, but do not guarantee success.

Osteo-plastic resections cause less deformity than ordinary excisions. *Langenbeck's first method*, namely, that which consists in resection of the nasal bones, has been performed several times with success, and is adapted especially to those cases in which the tumor occupies the nasal cavity, rather than the pharynx, and in which the attachments are well forwards. It certainly would not afford the requisite facility for reaching tumors which occupy the usual situation, as an examination of the cadaver alone will show. *Langenbeck's second operation*, in which portions of the malar and superior maxillary bones are temporarily displaced, is admirably adapted to the removal of those polypi which originate in the pterygo-maxillary fossa, and it is for this purpose that it was originally designed. But though it has been also done successfully for naso-pharyngeal polypi, it is inferior to several other procedures for this purpose. The operation itself is difficult of execution, unless the sphenopalatine foramen is abnormally dilated; and the pharynx is very imperfectly exposed, owing to the presence of the pterygoid process. These objections will prevent the operation from being extensively adopted.

Huquier's operation has been performed by its inventor, and, with slight modifications, by Cheever. Both patients recovered. The liability to recurrence of the disease after removal offers a strong argument against osteo-plastic operations generally.

Roux's operation involves great mutilation of the facial bones, and does not afford satisfactory access to the pharynx. To expose a tumor having broad attachments, it would be necessary to displace the maxillary and malar bones on both sides of the face, thereby greatly increasing the risks of the operation.

Cheever's operation [which involved *both* upper jaws] is ingenious, and, although it terminated fatally in the first instance in which it was performed, Sands agrees with its originator in thinking that there is no danger inherent in the operation itself that ought to prevent its repetition. [A successful case has since been reported by Tiffany.]

The objections that apply to *partial or total excisions* of the upper jaw, as a preliminary operation, are mainly owing to the disfigurement which they produce; in partial excision this is but slight. Sands remarks that these operations as a class, are remarkably successful. Lincoln,¹ that the result of a study of the table of cases² accompanying his paper, suggests a doubt as to the propriety of this conclusion. It will be found that among 28 cases treated by a section of the bones of the face, in several instances the growths returned, necessitating a repetition of the operation or the substitution of some other; and also that in 8 cases, or more than 28 per cent., death followed immediately, or in a few days.

Excision of the jaw certainly affords easier access to the pharynx than any of the other methods, and thus enables the operator to attack the pedicle with the maximum chances of success; accordingly, the probability of a recurrence will be correspondingly diminished. Neither the procedures through the mouth, nor any of the osteo-plastic procedures which have been described, permit that satisfactory exposure of the base of the skull which is afforded either by partial or total resection of the superior maxilla. From what has elsewhere been said, it must be evident that ample space is necessary, both for the extirpation of the tumor and for the prompt arrest of the hemorrhage that so often accompanies its removal. Another advantage of ordinary excision is, that a wide gap is left after the operation, through which the disease, should it recur, can be readily recognized and treated.

¹ Op. cit.

² This table is reproduced on page 823.

SYNOPSIS OF A TABLE OF ALL PUBLISHED CASES OF OPERATION FOR NASO-PHARYNGEAL POLYPUS (NASO-PHARYNGEAL FIBROMA)

FROM 1867 TO OCTOBER, 1883.

(Lincoln, Archives of Laryngology, vol. iv. No. 4, Oct. 1883.)

TUMORS OF THE NOSE.

823

No. of Operations.	Number and Sex of Patients.	Age of Patients.	Operations Involving Section of Facial Bones or the Laying Open of the Clefts Resulting from Previous Operations of this Character.	Removal by Knife, Scissors, Avulsion with Forceps, etc.	Removal by Écraseur or Ligature.	Removal by Injection or Causticization with Chloride Zinc.	Removal by Electrolysis.	Removal by Galvano-Cautery Écraseur. ¹
74	58	8 years, 2 14 " 6 15 " 6 16 " 3 17 " 5 18 " 3 19 " 2 20 " 1 21 " 2 22 " 1 23 " 2 25 " 1 26 " 1 30 " 1 33 " 1 35 " 1 39 " 1 40 " 2 41 " 1 42 " 1 45 " 1 47 " 1 48 " 1 52 " 2 54 " 1 55 " 1 Not stated,	No. operations, 39. No. patients, 28. No. cases in which recurrence is reported to have taken place within a year, 14. No. cases reported under observation for a year or more without recurrence, 4. No. cases in which there is no record subsequent to the operation, or a few months after, 13. No. deaths during or attributable to the operation, 8. In three other cases operation nearly proved fatal (Nos. 20, 23, and 46).	No. operations, 7. No. patients, 7. No. cases in which recurrence is reported to have taken place within a year, 0. No. cases reported under observation for a year or more without recurrence, 1. No. cases in which there is no record subsequent to operation, or a few months after, 5. No. fatal cases, 1 (No. 21).	No. operations, 12. No. patients, 11. No. cases in which recurrence is reported to have taken place within a year, 6. No. cases reported under observation for a year or more without recurrence, 4. No. cases in which there is no record subsequent to operation, or a few months after, 2. No. fatal cases, 0.	No. cases treated, 2. No. cases in which recurrence is reported to have taken place within a year, 1. No. cases in which there is no record after the discontinuance of treatment, 1. No. fatal cases, 0.	No. cases treated, 3. No. cases reported under observation for a year or more without recurrence, 1. No. cases in which there is no record after the discontinuance of treatment, 2. No. fatal cases, 0.	No. operations, 11. No. patients, 10. No. cases in which recurrence is reported to have taken place within a year, 3. No. cases reported under observation for a year or more without recurrence, 6. No. cases in which there is no record subsequent to operation, or a few months after, 2. No. fatal cases, 0.

¹ In this class is included one case treated by means of the actual cautery (No. 70).

Partial excision of the jaw, according to the plan of Maisonneuve, will in most cases fulfil all the indications presented. Partial excision affords an excellent view of the pharynx, and leaves the patient with very slight external disfigurement. The orbital plate and malar tuberosity being left intact, the eyeball does not descend from its normal position, and the prominence of the cheek remains—which is not the case after complete excision. The skill of the dentist can readily imitate the lost portion of bone, and the gap in the palate can be closed, partly by staphyloraphy, and partly by an obturator made of hard rubber.

Of all the operations mentioned, then, which are applicable to grave cases, Dr. Sands gives the preference to partial excision of the upper jaw, as the one which is adapted to favor the most complete removal of the tumor with the least practical disfigurement. In this view he is in accord with the majority of surgeons of the day.

CARTILAGINOUS GROWTHS have elsewhere been alluded to (page 801) as occurring not infrequently upon the septum, more in the form of general thickening of its cartilaginous portion than as distinct tumors, and often associated with deviation of the cartilage. Large cartilaginous tumors springing from either the ethmoidal cells or frontal sinuses are very uncommon, and but few instances are upon record.¹ They usually affect young persons, cause frightful deformity, and lead to the early death of the patient. When small, they may perhaps be removed by means of the knife, gouge, or chisel, through the nasal opening; but if large, with deep attachments to the base of the cranium, or, perhaps, lying in contact with the under surface of the brain, as is usually the case, operative interference is out of the question.

OSSEOUS GROWTHS.—Bony formations of various classes are found within the nasal passages. First, exostoses, developed from the bony portion of the nasal septum or floor of the nostril, which are common; likewise tumors springing from some neighboring bone and invading secondarily the nose; or growths which may be the result of strumous or syphilitic disease of the osseous framework of the nasal cavity, and into the formation of which cartilage may enter in variable proportion and disposition.² Second, ossified cartilaginous or sarcomatous growths. (Mackenzie.) And third, a remarkable form which is to be carefully distinguished from the true exostoses, whether cancellated, compact, or eburnated, and from the mixed bony and cartilaginous growths just alluded to; instances of this form are reported by Legouest, Duka,³ Michon,⁴ and Dolbeau,⁵ and the whole subject is elaborately treated of by Ollivier.⁶ In all such cases the bony growth is developed from between the layers of the nasal mucous membrane or periosteum which lines the cavities, independently of any apparent disease of the parts which envelop it, and always remains free and movable; it may take its origin in the frontal sinuses or in the nasal fossæ, and by slow growth may attain a considerable size. It has been suggested that these growths may be analogous in their mode of development and subsequent separation to the antlers of the *Cervidæ*. (Durham.) Thudichum⁷ adds that exostosis of the turbinated bones is an occasional complication of nasal polypus.

¹ See Ure, Stanley, and Prochaska (Disquisit. Anat.-physiol. Organismi. Corp. Human., p. 172. Viennæ, 1812); also, Cooper's Surgical Dictionary.

² Trélat and Dolbeau, Bull. de la Soc. de Chir., 1862, p. 261; and Morgan, Guy's Hosp. Reports, series i., vol. i. p. 403; *sequel*, series i., vol. vii. p. 491.

³ Path. Trans., vol. xviii. p. 256; vol. xix. p. 311, another case.

⁴ Mém. de la Soc. de Chir. de Paris, tome ii.

⁵ Bull. de l'Acad. de Méd., tome xxxi. p. 107.

⁶ Sur les Tumeurs osseuses des Fosses nasales. Paris, 1869.

⁷ Lancet, Sept. 1868.

Bony tumors vary somewhat in their character and formation; some have a hard, ivory-like density; others are soft and friable; they are often interspersed with small cavities, occupied with gelatinoid, fibrous, or cartilaginous matter; but whether compact or cancellated, they always present the characteristic arrangement of the Haversian canals. Their removal is effected by cutting off their attachments with the knife, saw, pliers, or chisel, either through the nose, or, if the mass be very bulky, by an opening through the face. (Gross, Mott.¹) Ollivier suggests that the cancellated variety may be crushed up, and then extracted without enlarging the natural opening of the nose. Cohen,² in a case of exostosis developed from the palatine ridge of the superior maxilla, and in the vomer, ground the offending mass away through the natural passage with the burr of the dental engine, the parts being exposed by detaching the overlying mucous membrane and periosteum, which were replaced after the exposed surfaces had been carefully polished by the corundum wheel. Similar cases have been reported to me by Clinton Wagner.

The curious "osseous tumors" above referred to, require free and complete exposure of the cavities in which they lie, and may then be turned out without difficulty. (Legouest.³) If allowed to remain *in situ*, they finally cut off their own nourishment by pressure, and slough out through the tissues which envelop them. (Hilton.⁴)

SARCOMATOUS GROWTHS.—The tendency which fibroid polypi, cartilaginous tumors, and even simple gelatinoid growths, occasionally exhibit to degenerate into sarcomata, has been alluded to; but aside from these sources, sarcoma may develop primarily, with all the characteristics belonging to its class. Its differential diagnosis from carcinoma is difficult: both present in the nasal cavities many appearances, and give rise to many symptoms, that are in common. The main points in differentiation have already been touched upon (page 813).

Sarcoma usually shows itself, in the nasal passages, as a dark-red, fleshy-looking, lobulated mass, with prolongations and attachments stretching in different directions; its consistence varies, being either of a dense hardness, or with a soft and fluctuating feel. It is exceedingly vascular, and its growth rapid, especially in children, where the adjacent cavities, particularly the cranium, orbit, and pharynx, are often invaded almost simultaneously.

It is unquestionably the surgeon's duty, especially in the earlier stages of the affection, to attempt the extirpation of the neoplasm by some one of the operative procedures which have been described. This extirpation must, however, be radical, and must be successful and complete at the first attempt, or disaster is sure to follow; recurrence of the tumor is always attended with increased rapidity of growth, and with marked access of malignancy.

CARCINOMA.—The rarity of true cancer originating within the nasal passages, is conceded by all writers. Watson⁵ holds that the recorded instances are, for the most part, either examples of fibrous or sarcomatous tumors that have undergone softening and degeneration, with perhaps fungous protrusion, or cases of encephaloid disease which has originated in the meninges or cranial bones, and which has made its way through the ethmoid and sphenoid bones, into the orbit and nostril.⁶ The disease occurs either in

¹ American Journal of the Medical Sciences, January, 1857, p. 35.

² Op. cit., p. 400.

³ Mém. de l'Acad. de Méd., 1865-66, p. 147.

⁴ Guy's Hosp. Reports, series i., vol. i. p. 495.

⁵ Op. cit., p. 286.

⁶ Out of fifty-one cases of meningeal cancer analyzed by Velpeau, seven presented themselves in the orbito-nasal region, and in several of these the tumor appeared in the nostril, and caused symptoms commonly referred to malignant polypus.

young children, or in those past middle life. Its destructive inroads are widespread and terrible, and, as it is necessarily fatal, palliative measures alone can be adopted; all experience deprecates any recourse to operative interference.

The remaining varieties of tumor that may occur in the nasal passages, are very infrequent, and demand but passing notice.

Adenoma is developed from the glands of the mucous membrane, and may not only attain a great size, but may reach from the nasal passages into all the adjacent cavities.

Neuroma.—A case is reported by Gerdy,¹ in which a neurilemmatous tumor, connected with the second branch of the fifth pair of nerves, made its way into the nostril through the sphenopalatine foramen. Attempts at evulsion, the growth having been mistaken for a nasal polypus, resulted in meningitis and death.

Echinococci.—Fraenkel² refers to the presence of these tumors, which he regards as of rare occurrence.

Cysts.—True cystic tumors occasionally occur in the nasal cavities proper, and originate in the lining mucous membrane. I have seen and treated one such case, in which the tumor, closely resembling an ordinary mucous polypus, both in color and configuration, was seen by posterior rhinoscopic examination to be situated in the left posterior naris; seized by the polypus-forceps, it burst, discharged its contents, and all vestiges quickly disappeared; there was no recurrence.³ A similar case, the cyst being located in the right posterior naris, is reported by Johnson,⁴ and others by Seiler⁵ and Ingals.⁶

NEUROSES OF THE NASAL PASSAGES.

The olfactory nerve is the only one upon whose integrity depends the sense of smell. After passing the lamina cribrosa of the ethmoid bone, its branches, as is well known, are distributed in the mucous membrane covering the upper part of the septum, to a limited extent, and more richly to that covering specially the upper turbinated bone and perhaps the upper part of the middle one. The epithelium of these parts has a special arrangement, also, which differs from that of the lower portion of the nasal passage, and which may have some special relation to the function of olfaction. The terminal branches of the nerve are probably in immediate connection with certain peculiar terminal organs, which receive olfactory impressions and conduct them to the nerve-fibres. Nothing certain, however, is known in regard to the central course of the olfactory nerves; the so-called external root contains the greater number of fibres, and may be traced centrally into the neighborhood of the island of Reil (Erb.) The first and second divisions of the fifth pair constitute the true sensory nerves of the mucous membrane of the nose; they conduct tactile and common sensations, but are uninfluenced by odorous substances.⁷ These anatomical and physiological facts have a direct bearing, as will be seen, upon the various neuroses to be considered. It may be appropriate to here likewise recall to recollection the necessity for carefully distinguishing between the sense of taste and that of smell, in investigating a supposed case

¹ Des Polypes, p. 110.

³ Phila. Medical Times, Dec. 15, 1883.

⁵ Phila. Med. Times, vol. xiv. No. 423, Feb. 9, 1884.

⁶ Chicago Med. Review, vol. ix. No. 5, Feb. 2, 1884.

⁷ See also Althaus, The Physiology and Pathology of the Olfactory Nerve. Lancet, May 14, 1881, *et seq.*

² Ziemssen's Cyclopædia, vol. iv. p. 171.

⁴ British Medical Journal, May, 1874.

of loss of the latter, and to the rules for determining whether such loss is limited to one nasal passage, or affects both. It is no unusual matter for individuals affected with anosmia to declare that the sense of taste is also lost, and this because they are unable to perceive differences of flavor, a matter of olfaction alone. Careful examination and test of the gustatory sense will show, however, that the taste of acid, sweet, bitter, and saline substances can be perceived—perception of flavor alone is in abeyance. In other words, if smell be lost and taste preserved, flavors can no longer be distinguished, though simple perceptions of taste remain. This is true, as a rule; but even though there be complete inability to appreciate odorous substances inhaled through the nose, perception of flavors may still exist in certain cases. This can only happen, however, when the posterior nares and passage between the velum and posterior pharyngeal wall are free; in cases where the anterior nasal openings and passages are occluded, the odorous particles of food and fluids reach the olfactory region through the posterior nares alone. Ogle¹ reports two interesting cases in which the posterior nares were obstructed in consequence of the adhesion of the soft palate to the posterior wall of the pharynx; in both, the sense of smell and power of perceiving flavors were completely lost. In one, an artificial opening was made through the soft palate, and both olfaction and perception of flavors were again restored as soon as the communication was established.

Loss of smell may affect one side of the nose alone; in such instances the patient may not be aware of his defect, and the surgeon can only prove it by carefully testing each olfactory region separately, the nostrils being alternately held closed. For this test, articles must be chosen that are truly odoriferous, and not irritant to the sensory fibres of the fifth nerve. Ammonia, snuff, and the like, are thus to be avoided, and the test made with cologne-water, musk, camphor, or any of the volatile essential oils. That the test may be complete, and the fact proven that complete anosmia exists, it is well to experiment likewise with the perception of flavor in the given case. Coffee, wine, liqueurs, and many other articles, depend for their agreeable flavor upon the participation of the sense of smell with that of taste. If complete anosmia exists, flavor is lost, as has been shown, even though the posterior nares be patent.

The neuroses referable to the nasal organ are those of olfaction, sensation, and motion.

ANOSMIA may be caused, in the first instance, by any condition of the nasal passages that gives rise to obstruction, or renders the action of odorous substances upon the olfactory apparatus impossible; and secondly, by impaired function or destruction of the nerve-filaments distributed in this olfactory region, or by impaired function or destruction of the olfactory bulbs themselves. It is understood that the term anosmia is applied only to such cases as those in which the intensity of the perception of smell is progressively diminished until extinguished, without the sensibility of the mucous membrane to irritant substances being affected; thus, tobacco, for instance, will cause sneezing, though its peculiar smell be not perceived.

Any obstruction to the entrance and free passage of air to the upper portions of the nasal passage, may constitute an efficient cause of anosmia. The commoner causes are probably chronic hypertrophy of the tissues, as seen in old standing cases of catarrh; the presence of thick, dry crusts and secretions, nasal polypi, and finally, as a common temporary cause, acute inflammation—coryza or influenza. Among the rarer causes may be mentioned anæ-

¹ Med.-Chir. Trans., vol. liii. p. 273. 1870.

thesia of the trigeminus, with diminished or suppressed nasal and lachrymal secretion, and hence an abnormally dry nasal mucous membrane, incompatible with the exercise of the full function of smell; occlusion of the nostrils from congenital or accidental causes; paralysis of the dilator muscles of the nostrils (paralysis of the portio dura of the seventh pair); and occlusion of the pharyngeal or post-nasal cavities as the result of syphilitic cicatricial contraction, or other mechanically occluding causes elsewhere mentioned.

Ogle dwells upon the importance of the pigment of the olfactory region for the integrity of the sense of smell, and quotes an interesting case in support of his views.¹

Various pathological lesions, which involve—perhaps destroy—the terminal distributions of the olfactory nerve, secondarily give rise to anosmia. Such lesions are not infrequently seen in the various idiopathic, traumatic, and constitutional affections of the nose already alluded to. Watson believes that certain cases of anosmia, after severe catarrhal attacks with violent sneezing, may be due to local mischief implicating the fibres of the nerve in the olfactory region,² or to hemorrhage which has taken place into the olfactory bulbs. In Virchow's Archives,³ a case is recorded in which the continued, accidental inspiration of the fumes of ether caused a gradual failure of the sense of smell, and at last its total abolition, the effect being attributed to the continuous contact of the drug with the minute branches of the olfactory nerve.

Finally, cerebral disease, either directly or indirectly involving the olfactory bulbs, and impairing their nutrition and functional activity, gives rise to loss of smell. These cases, too, are not infrequently associated with subjective derangements of olfaction, the subjective odor being usually complained of as offensive.

Hughlings Jackson calls attention to effusion into the lateral ventricles as a possible cause,⁴ through pressure on the olfactory bulbs. Blows upon the head, whether on the forehead, parietal region, vertex, or occiput, have long been recognized as causes of anosmia. Hilton attributes this result to rupture of the olfactory bulbs, or their separation from their beds, owing to the fact that they lie directly on the floor of the cranium, unprotected by a cushion of cerebro-spinal fluid, as are the parts of the base of the brain behind the bulbs. Ogle believes that it is due to rupture of the olfactory nerves as they pass from the bulb through the perforations in the ethmoid bone. The further deductions and conclusions reached by him, in his admirable article, may be thus summarized: Anosmia of the affected side is present in every well-marked case of facial palsy. He believes that the external root of the olfactory nerve is the only one directly concerned in olfaction, and that it depends upon the degree in which this root or its central termination has been disorganized, whether the loss of smell is complete or partial. In support of this view, he cites an observation of M. Serres⁵—founded on the results of nineteen post-mortem examinations of the bodies of paralytic patients—that lesion of the external is much more efficacious in determining anosmia than is lesion of the internal root. Wickham Legg⁶ and Hybord⁷ have shown that anosmia may not develop until several months after an injury to the skull, and then as the result of an extension of inflammatory or other processes. Prevost has demonstrated degeneration and atrophy of the olfactory nerve as the cause of senile anosmia. Notta⁸ has reported instances of congenital loss of smell, in which the absence of an olfactory tract was shown

¹ Am. Jour. Med. Sci., 1852.

² Archiv für path. Anat., Bd. iv. S. 41. 1867.

³ Anatomie Comp. du Cerveau, t. i. p. 295.

⁴ Arch. Gén. de Méd., Mars, 1874.

⁵ Recherches sur la Perte de l'Odorat. Arch. Gén. de Méd., Avril, 1870.

⁶ Op. cit., p. 337.

⁷ Med. Times and Gaz., Oct. 17, 1874.

⁸ Lancet, Nov. 8, 1873.

to be the cause by Rosenmuller and Pressat. Cases of anosmia which accompany aphasia and dextral hemiplegia, and are always limited to the left nasal cavity, are to be credited to Jackson, Fletcher, Ransome, Ogle, and Erb. The latter holds that the loss of smell occurring so frequently with hysteria is of central origin, and associated, as a rule, with loss of taste and with cutaneous and muscular anæsthesia. The anosmia of the insane may likewise be attributed to central lesion.

Treatment, as a rule, is not encouraging in its results. If the cause of the anosmia be central, its cure is probably hopeless; while if it be dependent upon mere mechanical obstruction to the entrance of the odoriferous particles to the olfactory region, it can be relieved, in the majority of instances, by removal of the impediment, by the means alluded to when treating of the various conditions of the nasal passages which give rise to occlusion or obstruction. Treatment must, then, in many instances at least, be limited to that of the primary disease, and to the removal of ascertained and present causes. Direct treatment of the affected parts, viz., the upper portions of the Schneiderian membrane, should always, however, be undertaken in the hope of success, and electric excitation by means of the interrupted galvanic current is indicated if treatment of the primary cause is not followed by restoration of the sense. Cohen¹ has found that, under certain circumstances, the only way in which he could arouse the sensation of smell was by using the covered negative electrode in the nasal passage, and the positive electrode over the course of the sympathetic nerve behind the angle of the jaw. Moller² applies strychnia with a brush to the nasal mucous membrane with good results. Notta gained only negative results with irritating snuffs, but calls attention to an important fact that should be remembered, viz., that many chronic cases recover even without any treatment.

HYPERÆSTHESIA.—Abnormal acuteness of smell may exist to such a degree as to cause intense annoyance and even distress to its unfortunate possessor. Numerous well-authenticated and curious examples are upon record, as, for instance, that of Anne of Austria, who fainted upon inhaling the odor of roses. But, on the other hand, many absurd claims are based upon the alleged acuteness of the sense: thus, it has been claimed that smell alone is adequate to the recognition of syphilis; that the difference between pneumonia and bronchitis may be detected by the nose alone; and even that recent participants in coitus may be distinguished by their peculiar odor.³

Other facts in relation to increased development of this special sense are of more diagnostic and practical value. Hysterical patients not infrequently can distinguish the most minute traces of odorous substances; subjective sensations of smell occur both in epileptics,⁴ when they usher in the seizure, and in insane patients;⁵ nervous disorders of various kinds, as well as the most various forms of cerebral disease,⁶ are occasionally complicated by derangements of olfaction; and tumors, softening, and degeneration of the olfactory nerve, are associated with like phenomena, which disappear with the complete destruction of the nerve and the establishment of anosmia.

STERNUTATIO, OR EXCESSIVE SNEEZING, may be the direct result of simple irritation of the Schneiderian membrane, especially if this be hyperæsthetic,

¹ Op. cit., p. 403.

² Rev. des Sci. Méd., Oct. 1876.

³ See also Isham, On Smell in the Diagnosis of Disease (Cincinnati Lancet and Clinic, Oct. 9, 1875); and Clinton Wagner, On Smell, hygienically and medico-legally considered (The Æsculapian, Feb. 1884).

⁴ Hughlings Jackson, Med. Times and Gaz., Aug. 13, 1864.

⁵ Forbes Winslow, On Obscure Diseases of the Brain, etc.

⁶ Manigault, Dubois, Westphal, Sander, Schlager.

the stimulus being transmitted through the fifth nerve to the medulla, and thence reflected, mainly to the muscles of respiration; or the cause may be central, as in the curious cases where it is excited by the emotions: thus, Stalpliat van der Weil¹ reports instances in which coitus was always preceded by violent paroxysms of sneezing;² Schubart, one of a young girl, who for several nights suffered from fits of sneezing, repeated three hundred times and more on each occasion; Albrecht, again, relates one of an infant in whom sneezing occurred one hundred times an hour, and caused death (Watson); and Mosler, the case of a girl with an ear affection, a sequel of typhoid fever, where the paroxysms lasted twenty-four hours. More modern instances also are not wanting in profusion.³

As a rule, the affection, if it may be so termed, is an unimportant one, especially in the first class of cases alluded to; but that serious results may follow prolonged and violent attacks of sneezing can be readily appreciated. Epistaxis, hæmoptysis, menorrhagia, and even cerebral hemorrhage, have been known to ensue, as well as, in rarer instances, amaurosis from retinal hemorrhage, epilepsy, abortion, and sudden death from rupture of an aneurism. (Watson, Cohen.)

Treatment.—In many cases of hyperæsthesia dependent upon the central causes outlined above, the treatment of the symptom is useless, being unattended by any good result. If sneezing be dependent only upon hyperæsthesia of the mucous membrane, the local use of sedative ointments, such as stramonium, aconite, and camphor, will play a useful part. If due to hysteria, preparations of assafœtida and valerian (Cohen), valerianate of iron, and the use of a weak solution of aq. laurocerasi, snuffed up the nostrils (Mayer), and the inhalation of tobacco snuff (Gray), may be employed; while if it occur in the course of a neuralgia of the facial nerve, sedatives are indicated, with tonics.

SPASMODIC TWITCHING OF THE NOSE, if not the result of mere habit, probably depends upon chorea, and is associated with similar convulsive muscular contractions of the face, or even of the body. The indications for treatment suggest themselves.

PARALYSIS OF THE NOSTRILS is probably a partial manifestation of paralysis of the facial nerve, though it may exist, it is true, but rarely, as a purely local affection. It amounts to a serious inconvenience only when both nostrils are affected, and oral respiration becomes a necessity. The nature of the treatment must depend upon the cause of the paralysis; locally, the use of the electric current is indicated.

Nasal Cough, and the Existence of a Sensitive Reflex Area in the Nose.—Attention has been called, in a previous section of this essay, to the fact that violent or paroxysmal cough is not infrequently a symptom of nasal disease, and is specially attendant upon those pathological conditions which affect the inferior turbinated bones. J. N. Mackenzie⁴ has investigated the question both experimentally and clinically, and in an interesting paper has given his results or conclusions as follows:—

¹ Obs. Rares de Médecine, etc.

² See, also, J. N. Mackenzie, Irritation of the Sexual Apparatus as an Etiological Factor in the production of Nasal Disease (*Am. Jour. Med. Sci.*, April, 1884).

³ Russell, case due to cerumen (*Brit. Med. Jour.*, vol. ii. p. 937. 1879); Woakes (*Lancet*, March, 1880, p. 253); also *Lancet*, Nov. 1873, p. 864; *Brit. Med. Jour.*, Jan. 1889, p. 90; *Ibid.*, Dec. 1879, p. 1021.

⁴ *Am. Jour. Med. Sciences*, July, 1883.

1. In the nose there exists a well-defined sensitive area, the stimulation of which, either through a local pathological process, or through the action of an irritant introduced from without, is capable of producing an excitation which finds its expression in a reflex action or in a series of reflected phenomena. 2. This sensitive area corresponds, in all probability, with that portion of the nasal mucous membrane which covers the turbinated corpora cavernosa. 3. Reflex cough is produced only by stimulation of this area, and is only exceptionally evoked when the irritant is applied to other portions of the nasal mucous membrane. 4. All parts of this area are not equally capable of generating the reflex act, the most sensitive spot being probably represented by that portion of the membrane which clothes the posterior extremity of the turbinated body, and that of the septum immediately opposite. 5. The tendency to reflex action varies in different individuals, and is probably dependent upon the varying degree of excitability of the erectile tissue. In some, the slightest touch is sufficient; in others, chronic hyperæmia or hypertrophy of the cavernous bodies seems to evoke it by constant irritation of the reflex centres, as occurs in similar conditions of other erectile organs. 6. This exaggerated or disordered functional activity of the area may possibly throw some light on the physiological destiny of the erectile bodies. Among other properties which they possess, they act as sentinels to guard the lower air-passages and pharynx against the entrance of foreign bodies, noxious exhalations, and other injurious agents to which they might otherwise be exposed.

INJURIES TO THE NOSE.

FRACTURES OF THE NASAL BONES are caused by severe blows or falls upon the organ. If the force comes from before and from above, a transverse fracture is usually the result, within from three to six lines of the lower and free margins of the nasal bones, and the fragments are simply displaced backwards; or if the blow is received partially upon one side, they are displaced more or less laterally. Greater force will generally break the ossa nasi transversely, and a little above their middle, while at the same time the nasal processes of the superior maxillary bones may be slightly involved; and finally, the amount of force requisite to break in the nasal bones at their upper third is very great. Hamilton¹ asserts that if they do yield at this point, there is no doubt but that the base of the skull must yield also, and that patients can hardly be expected to recover from so severe an accident. In children the nasal bones may be spread and flattened, the lateral margins not being depressed or displaced, but only the mesial line or arch forced back so as to press aside the processes of the superior maxillæ. This deformity may become permanent. (Hamilton.)

The attendant injury to the soft parts, and the rapidity with which swelling ensues after these accidents, render the diagnosis at times difficult. Careful inspection and palpation, if at once instituted, rarely fail, however, to establish the fact, and crepitation, which can usually be felt, especially if the fracture be multiple, confirms it. Bleeding, which may be so profuse as to endanger life, commonly attends the accident, and if the lachrymal bone be involved, emphysema of the eyelids and of the cellular tissue of the orbit, due to an escape of air from the nose, will exist.

Gross² calls attention to the fact that sometimes violent cephalic symptoms attend these fractures, depending upon the intimate connection between the nasal and frontal bones, which permits the jarring effects of the blow or fall to be communicated to the brain and its envelopes. Danger to life is to be apprehended, however, only when there is serious cerebral involvement, as when the lesion is associated with fracture of the cribriform plate of the

¹ Fractures and Dislocations, p. 90.

² System of Surgery, vol. i. p. 946.

ethmoid bone, separation of the dura mater at the anterior part of the base of the skull, copious effusion of blood, or severe concussion of the brain. Under such circumstances the patient may die from shock, from compression, or from inflammation.

Reduction of the fractured bones if undertaken early, before swelling has masked the field of operation, is usually readily accomplished. External manipulation alone may succeed in replacing the fragments, but usually the combined method—the finger externally, and some small instrument, a straight steel director or a sound passed up into the nasal cavity—will be necessary. By these means the loose fragments are gently pressed back into position; to hold them there, however, is no easy matter; the swelling of the soft parts has a constant tendency to depress them, unsupported, as they are, by any counter-force. The use of pledgets of lint or compresses within the nose, is deprecated by all modern writers, as practically useless and painful to the patient. Hamilton only advises them in cases where the amount of comminution of the bones is great. The same is true of canulas, hollow bougies, and the like. When the fragments exhibit a tendency to become depressed or to fall asunder, after they have been replaced, Gross recommends that they be held in position by a stout adhesive strip carried across the bridge of the nose from one cheek to the other, and Hamilton uses nicely adjusted compresses made of soft cotton or lint, and secured upon the outside of the nose with delicate strips of adhesive plaster, or rollers, to accomplish the same result. Mason,¹ in fractures of the nasal bones with depression of the bridge, and also of the nasal processes of the superior maxillæ, recognizing the difficulty of holding the fragments in place after reposition, suggests the following method: pass an ordinary surgical needle, nickel-plated or gilded, and by means of a strong needle-holder, through the line of fracture of the nasal processes on either side. After the parts have been replaced in position, this affords not only a posterior support to the nasal bones, but acts as a tie-rod holding together the sides of the nasal arch. To complete the dressing, a small strip or ribbon of pure rubber-bandage is placed over the bridge of the nose, by puncturing either end on the head and point of the needle, giving the rubber sufficient tension to exert a gentle downward and lateral compression, but not enough to interfere with the circulation of the part, or to exert injurious pressure on the fragments. At the end of about the sixth day the needle may be withdrawn, for the less serious forms of these fractures are repaired with great rapidity and without the interposition of provisional callus, and therefore the need of constant supervision and readjustment of the apparatus, which is required in whatever method be employed, will not long tax the surgeon. The amount of deformity sometimes resulting from apparently an insignificant amount of injury, warrants, however, careful attention to both. To relieve the deformity resulting in old cases where fractures of the nasal bones have either been left unreduced, or where the result of treatment has been bad—no unusual occurrence—various methods have been suggested. That recommended by Adams in cases where the septum is also displaced, has been alluded to elsewhere. Weir,² not satisfied with the results gained by Adams's method of refracturing and readjusting these old fractures of the nasal bones with lateral displacement, and believing, as the result of several trials, that the Adams forceps is too large at its end to be satisfactorily carried up under the nasal bones, and that the fracturing force is not ample enough, has devised a new procedure. This is nothing less than to perform an osteoclastic operation, or, in more ordinary words, to make an incision—not directly

¹ Annals of the Anat. and Surg. Society. Brooklyn, March, 1880.

² Med. Record, March 13, 1880.

to the bone, but bevelled, as Packard, of Philadelphia, has suggested, as creating the least cicatrix—not more than one-eighth or a quarter of an inch long, over the greatest convexity of the bony deformity and parallel to the free border of the nose, so as to, as nearly as may be, strike the naso-maxillary junction, and then, by the introduction through this small cut of a very narrow chisel, to cut through the bone with a few strokes of the mallet; if the tilting action of the imbedded chisel prove insufficient to loosen the other side of the nose, it is only necessary to chisel that side also through the same incision, which is the only one required. Replacement can now be effected with ease and rapidity, and the retention of the nose in its corrected position is readily accomplished. If depression also exist, the elevation of the refractured bone is brought about by pushing it upwards by an instrument from within the nose. A piece of sticking plaster rolled up with the sticky side out is now laid along the nose on its formerly prominent side, to form a compress, and another strip drawn across this and the face, to hold everything snugly in its place. A nose truss, a modification of that of Adams, may be worn for a few days.

DISLOCATION OF THE NASAL BONES is a very infrequent accident, and cannot occur except as the result of direct violence, nor unless associated with dislocation of the septum. Fracture of the cribriform plate of the ethmoid bone may likewise coexist, and may very seriously complicate the condition, through the injury which the displacement of its fragments may inflict upon the brain or its membranes.¹ Considerable force is necessary to replace the nasal bones when dislocated backwards, mainly because they are jammed between the nasal processes of the superior maxillary bones, which hold them tightly. Once replaced, however, by the same means that are used in fracture of the nasal bones, no retentive apparatus is required.

WOUNDS OF THE NOSE, whether they be contused, incised, or lacerated, demand careful treatment, in view of the possible future deformity. In the case of incised or lacerated wounds, accurate coaptation of the edges of the wound by means of numerous fine sutures, the readjustment of the parts in their normal position, and their retention by means of delicate adhesive strips, demand careful attention and good surgical skill. Primary union is the rule, unless there be much contusion of the parts. The question whether an incised wound, resulting in partial or total separation of a portion of the nose, can be followed by complete union of the severed part even after it has been separated from the main portion of the organ for a considerable time, is answered in the affirmative by Watson,² and a number of curious and interesting illustrative cases are given by him in support of this position. In any doubtful case, it will be wise, he holds, to give the patient the benefit of the doubt. The detached portion should be carefully cleansed, the raw surface of the stump revived by scarification, and the parts adapted to each other, and then retained in position by strapping—if possible without sutures. Cotton-wool steeped in collodion, used as a dressing to the edges of the wound, has the advantage of rendering a support to the parts which other dressings do not.

INJURIES TO THE NOSE WITH THE LODGMENT OF FOREIGN BODIES, are almost exclusively met with as the result of gunshot-wounds with penetration and lodgment of the ball. The history of the case, the presence of scars or fis-

¹ Longuet (On the Luxation of the Nasal Bones), *Rec. de Mém. de Méd.*, etc., tome xxxvii. p. 280. Paris, 1881.

² *Op. cit.*, p. 295.

tulæ, and the result of a careful exploration of the parts as detailed when speaking of the treatment of foreign bodies in the nose, usually leave no room for doubt as to the nature of the injury, even though a considerable time has elapsed since its reception. Interesting cases are given of this form of accident by Williamson¹ and Lawson;² in the case recorded by the latter, the right cavity of the nares was necessarily laid open by incision, to afford space for the extraction of the foreign body, a portion of the breech of a fowling-piece that had exploded in the patient's hands. A somewhat similar case, reported by Noyes, is alluded to elsewhere in this essay.

BURNS AND SCALDS OF THE NOSE are of special importance, in view of the possible distortion of the organ, of the partial closure of one or both nasal orifices by cicatricial tissue, or of the results of cicatricial contraction if the lesion be at all extensive. Their ultimate effects exceed therefore in gravity those which are immediate, and are to be guarded against during the healing process by promptly meeting the indications that suggest themselves. The operation necessary for the restoration of the calibre of the nostril has already been considered.

DEFICIENCIES AND DEFORMITIES OF THE NOSE.

CONGENITAL ABSENCE OF THE NASAL ORGAN is a rare condition. A case is reported by Maisonneuve,³ in which the nose of a female infant of 7 months was replaced by a plane surface, merely pierced by two small holes. Other cases are said to be upon record, but I am unable to find them. Holmes regards the malformation as incurable.

CONGENITAL CLEFTS AND FISSURES OF THE NOSTRILS are simply prolongations of the natural opening, outwards into the cheek, or upwards towards the angle of the eye. They are very unusual, and as a rule can be closed by plastic operations.

DOUBLE NOSE.—Dr. S. W. Gross has related to me the particulars of an interesting case of this unusual condition. The auxiliary organ, apparently an outgrowth of the first, was of about one-half its size, and into it the tear-duct opened. Borellus⁴ mentions a similar case, and Bartholinus⁵ one in which a little tumor, like a second nose, grew on the root of the principal or normal one. (Watson.) There would probably be no great difficulty, in such instances, in remedying the deformity by a simple operation.

CONGENITAL OCCLUSION of the *nostrils* and of the *posterior nares* has been elsewhere considered (see page 796).

SLIGHT DEFORMITIES IN THE SIZE AND POSITION OF THE NOSE are commonly seen. The central portions of the face and skull are but slowly developed, when compared with the rate of growth of other parts, and this is particularly true of the frontal eminences and the sinuses communicating with the nose. Thus, the latter organ in the infant always presents a flattened appearance, which may persist in later years. The same reason suffices to account for other well-known deviations from the normal contour. Harrison Allen⁶

¹ Quoted by Watson, *op. cit.*

³ Bull. de Thérap., tome xlix. p. 559. 1855.

⁴ Hist. et Obs. Medico-physic. Cent. III., Obs. 43.

⁶ Phila. Med. Times, Dec. 6, 1879.

² Diseases and Injuries of the Eye, 2d ed.

⁵ Hist. Anat. Rar. Cent. I. Hist. 25.

has called attention to an asymmetrical rate of growth of the vistral arches, which prevents the perfect shaping of the oral and nasal cavities: one arch being more actively developed than its fellow, one nasal cavity will be found narrowed and obstructed, the other abnormally large, and the septum deflected from the median line. In such cases of congenital deformity, the teeth also are irregular, especially the permanent incisors; the two halves of the upper dental arch are V-shaped, and the vault of the mouth is high and narrow. The nose will thus be rendered misshapen, prominent, and projecting, not only on account of the high-pitched hard palate which pushes its parts forward, but likewise on account of the retarded growth of the perpendicular plate of the ethmoid, which prevents its normal development posteriorly. The marked influence which the cartilaginous septum plays when congenitally misshapen or distorted, in producing a lateral distortion of the nose in its external contour, has been already alluded to (see page 799), and the operative measures necessary for the relief of that condition have been described. When nasal bones and alæ as well as septum are laterally distorted, surgical attempts at remedying the condition are not attended with much success; and, unless the deformity be excessive, which is rarely the case, had better not be undertaken. Various "nose-machines" have been devised to effect a cure by straightening the organ mechanically; one consists of two parallel plates of iron, well padded inside, and properly curved so as to adjust themselves to the shape of the nose to be operated upon. The upper and lower portions of these plates are furnished with screws, passing horizontally from one plate to the other, so that they may be properly adjusted as regards the degree of compression. Another apparatus consists of a metallic arm, fastened to a head-band, and furnished at its end with a small pad, which, when the instrument is in position, is so arranged as to press directly upon the point of greatest convexity of the distorted nose; the degree of compression is regulated by means of a cog-wheel joint. It is possible that, could the patient be induced to wear either of these forms of apparatus for a sufficiently long time, some change in the position of the nasal parts would follow.

THE SEVERE DEFORMITY WHICH FOLLOWS INJURIES AND CERTAIN DESTRUCTIVE DISEASES, such as lupus, erosive syphilitic ulcer, and the like, and which involves not unfrequently parts of the cheeks and lips, as well as the whole of both internal and external parts of the nose, is commonly such as to tax both the skill and the ingenuity of the surgeon who is required to repair the damage sustained by the loss of the parts, to remove the disfigurement produced by the destructive disease, or by violence, or, it may be added, to remedy the deformities of congenital malformation. Fortunately, however, the results obtained by operation within the last half century in such cases, are among the most satisfactory achievements of surgery. In extreme cases, where the external nose has been entirely destroyed, the hideous and disfiguring chasm left in the face may be to some extent, in probably all cases, covered in by operation; it can at least be hidden by an artificial organ, even where the natural and necessary framework of cartilage and bone is altogether lost. The modern surgeon does not despair of success in forming at least a slightly if not beautiful nose. Where some portion only of the organ, usually its extreme point, is wanting as the result of accident or disease, or where depressions with loss of substance exist as the result of syphilis, a rhinoplastic operation of some nature is indicated, and is often, by the ingenious methods of modern surgery, rendered a brilliant success. The details of the various methods which are employed in cases of this kind, are fully considered in

various surgical works, notably that of Buck,¹ and hardly come within the scope of this article. [See Appendix, page 844, *infra*.]

INJURIES AND DISEASES OF THE FRONTAL SINUS.

Direct violence expended upon the forehead between the eyes, or upon the superciliary projections, may cause either a simple, a compound, or a comminuted fracture of the walls of the frontal sinus.

SIMPLE FRACTURE.—A simple fracture at this point offers a more favorable prospect than fractures of the skull in general, on account of the space which exists between the skull walls; but such a case should be carefully watched, and a guarded prognosis given, until the exact extent of the lesion is known. In the absence of all cerebral symptoms it is not an important one, and its only unfavorable result may be an emphysematous condition of the scalp, face, and eyelids, which occurs from the escape of air from the nose into the surrounding connective tissue. When the outer table is depressed, it should be elevated to prevent subsequent disfigurement.

COMPOUND AND COMMINUTED FRACTURES are usually the result of gunshot wounds, blows, stabs, or explosions, and may be complicated by the lodgment of a foreign body.² The results are more serious, but not necessarily fatal, even when the posterior wall of the sinus is fractured, and the dura mater exposed. The indication of course is at once to remove the foreign body and all loose fragments of bone, to do which it may be necessary to trephine or cut away with bone-forceps a part of the overhanging edges of the cavity, and thus afford space for extraction. Simple antiseptic dressings are then applied, and the wound kept well drained, until cicatrization is complete. As a result of such injuries, fistulous openings may remain through which air passes, and these may require plastic operations for their closure; or if cicatrization has been complete, but bony defect remain below it, the skin will be swollen out into an elastic, crepitating tumor, whenever the patient blows his nose. (Dupuytren.) The use of a pad and compress will usually, however, effect a cure in these cases, which are rare.

ACUTE INFLAMMATION, with or without resulting *abscess*,³ is usually due to tertiary syphilis, or to the extension of catarrhal inflammation from the nose, through direct continuity of structure; it may also follow the use of forcible injections high up into the nasal passage, or the use of the nasal douche. In these latter cases, a continuance of the exciting cause may lead to a chronic inflammation of the sinus (chronic abscess or mucocoele) accompanied by a purulent or muco-purulent discharge from the nose, extremely difficult to relieve and often offensive in its character, and may result in permanent distension of the cavity, displacement of the eyeball, if the outlet of the sinus become closed by swelling or by plugging with inspissated mucus or crusts, and deformity of the face. In acute inflammation also, especially if pus be formed, all of the symptoms to which it gives rise are much aggravated if communication between the anterior ethmoidal cells and the nasal passage is cut off by acute swelling of the mucous membrane, so that the secretions, instead of finding a ready exit through the nose, are pent up, causing marked

¹ Reparatve Surgery. New York, 1876.

² For a number of interesting examples, see Watson, Diseases of the Nose, p. 129, and appendix.

³ See Hartman on Empyema of the Frontal Sinus. Deutsch. Archiv für klin. Med., 1877, S.

distension of the parts, deformity of the eyeball, and swelling of the upper eyelid. In such a case, if it be not evacuated by artificial means, pus will usually pass into the other sinus by breaking down the septum, or may possibly perforate through the anterior wall, if it cannot find its way out by the nose, which is the most favorable direction. The possibility also must always be borne in mind, that an acute abscess may make its way into the cranial cavity through the posterior wall of the sinus, or, if the orbit be involved, through the optic foramen, and that the brain may thus become implicated, especially in tertiary syphilis.¹ Bizet² reports such a case of perforation from syphilitic abscess, in which there was a hernia of the Schneiderian membrane, through the aperture.

The *symptoms* of acute inflammation and of abscess are usually marked: pain, weight and fulness over the forehead; headache, and all the local symptoms of an acute coryza, are early complained of. The formation of an abscess is indicated by an accession of the local swelling and an increase in the local suffering, high febrile disturbance, excessive headache, rigors, and delirium; even semi-coma may result, and perhaps paralysis of the limbs of the opposite side, showing the course taken by the pus. (Watson.) An erysipelatous blush appearing upon the surface is regarded by many authors as an almost unerring sign of the nature of the disease.

Treatment by leeching over the affected sinus early in the acute form of the disease, may abort it; if it fail, pus form, and the case become urgent, as shown by the cerebral disturbance and excessive local inflammation, an attempt may be first made to establish a communication with the cavity of the sinus through the nose, and thus draw off the accumulated matter, by passing a stout probe up through the natural channel with some force; if this fail, an incision is made, directly through the swollen tissues down to the bone, and a small trephine is then used, to make an opening into the most dependent part of the sinus. If there be no evidence of swelling or pointing at any one place, the instrument should be applied at the upper and inner angle of the orbit. The opening made, the cavity may be washed out with warm, disinfectant, astringent, anodyne, or detergent solutions, and a drainage tube inserted. If necrosed bone be present, as in syphilis, it must be carefully removed; much relief may be given, also, by the use of various sedative ointments applied to the nasal mucous membrane, by means of a probe wrapped with cotton. Cohen recommends one of stramonium, or simple cerate in which a few grains of morphine to the ounce have been well incorporated. Chronic abscess, or mucocoele, in its early stage, resembles very closely a bony tumor; if it has lasted any length of time, it usually causes either an absorption of the expanded portion of bone over it, or renders this so thin that it is readily compressible; an exploratory puncture is thus easily made into the tumor, and its true nature established; a direct incision will now serve to free it of its contents, and attempts must then be made to establish, either by the natural way or by an artificial puncture, communication with the nasal passage; and this must be kept open by means of a drainage tube, until its permanency has been established.

DROPSY OF THE FRONTAL SINUS, cases of which have been reported, is probably of the same nature as mucocoele, and requires the same treatment.

TUMORS OF THE FRONTAL SINUS.—*Cystic growths*, which are more frequently found than tumors of any other variety, may be serous, hydatid, or steatomatous in their nature; they may occur at any age, or even be congenital;

¹ Richter, *Observat. chir.* Fasc. ii.

² *Gaz. Méd. de Paris*, p. 663. 1863.

of the hydatid and steatomatous varieties, cases are reported by Langenbeck¹ and Brunn, in addition to several instances collected by Demarquay.² The diagnosis is necessarily obscure, until the growth of the cyst, which resembles a chronic abscess in its development, has so thinned the anterior wall of the frontal sinus that fluctuation can be detected, and an exploratory puncture made. The contents of the cyst may then be evacuated, and its sac either excised or stimulated to contraction by the use of an injection of iodine or some astringent wash, or it may be pierced through into the nasal passages, for the establishment of thorough drainage, as in chronic abscess.

Myxomatous or *gelatinous polypi* may either be developed within the frontal sinus, or extend into it from the nose, causing by their growth, in either case, deformity, attenuation of the bony walls, and pain. They are commonly single, but may be multiple. Seven examples of polypi of all descriptions—including the *fibrous* variety, which is very rare, but which may by its rapid growth extend into all the neighboring cavities, even that of the cranium—are reported by Demarquay; and additional cases of interest may be found detailed by Watson³ and Leveret.⁴ Viallet and Rouger report a case in which a polypus was associated with an exostosis of the cavity. The diagnosis having been established, the removal of the growth is effected by either the knife or the gouge, after the trephine and a crucial incision through the skin have given direct access to it.

Osteomata,⁵ curiously enough, have a peculiar preference for this region of the body, but constitute a very rare variety of tumor. Composed either of cancellated tissue, or of a compact tissue which renders the growth hard, ivory-like, or eburnated, and developed in the diploë of the frontal bone, they may attain a considerable size and occasion much distortion of the parts. Diagnosis as to their nature is not always easy. Attention has already been called to the fact that the tendency of all affections of the frontal sinus is, in the first instance, to cause distension of its bony walls, and thus to simulate very closely a bony tumor. The slow progress, unyielding hardness, and absence of inflammatory symptoms in true bony growths, will serve, in a short time, however, to render their true character plain. Occasionally, when small, they may readily be extirpated through an external incision made into the anterior wall of the orbit, or into the sinus; but the fact that they often extend backwards as well as forwards, even into the cranial fossæ, involving both bones and membranes, will render the surgeon cautious in undertaking operative interference which may be both difficult and dangerous. In many, perhaps a majority, of cases, if we may judge from those recorded, an operation is out of the question.

Malignant disease of a *sarcomatous* character, is, according to Gross, more common than is generally imagined. *Epithelioma*, when found in the frontal sinus, will usually have extended from some of the adjacent structures. Of *scirrhus*, *colloid* and *melanotic cancer* of the sinus, we possess no examples recorded in literature.

The development of any of the varieties of tumor here enumerated is attended by certain characteristic appearances; the external distortion in the configuration of the frontal sinus and its adjacent parts, often to such an extent as to produce the most hideous deformity, has already been alluded to, while absorption of the bony walls by the continued pressure, displacement of the eyeball outwards or downwards, distortion of the nose and of various

¹ Mackenzie, Diseases of the Eye, p. 16.

² Tumeurs de l'Orbite, p. 95.

³ Op. cit., p. 139.

⁴ Observations sur la Cure de plusieurs Polypes, p. 235. Paris, 1749.

⁵ See Boenhaupt (Case of osteoma of the left frontal sinus, with remarks on osteotomata developing in the accessory cavities of the nose), Arch. für klin. Chir., Bd. xxvi. S. 589. 1881.

other parts of the face, œdema and tumefaction of all the tissues, impaired vision, epistaxis, profuse discharge from the nasal passages, and intense headache—readily mistaken in the earlier stages for the manifestations of a cachectic or syphilitic cephalalgia—with compression and ultimate perforation of the bony structures at the base of the skull, and involvement of the anterior lobe of the cerebrum, with serious cerebral disturbance, are, unfortunately, but common results.

FOREIGN BODIES IN THE FRONTAL SINUSES.—The entrance and lodgment of foreign bodies in these cavities, as the result of gunshot wounds or other injuries, have been referred to. Reference must now be made to the presence of living insects, flies and worms, which either crawl up from the nasal fossæ, or are developed from ova, deposited directly within the sinuses or introduced in the act of smelling certain flowers or fruits upon which they have been placed by the insect. (Saltzman.) Fatal disease from such causes is said to be not rare in some countries, notably in India, where it is called *Peenash*.¹ The symptoms of their presence are well marked, and consist in continuous or intermittent headache, located over the frontal sinus, cerebral excitement and maniacal delirium, fainting, sudden vertigo and even sudden and temporary blindness, a profuse muco-purulent or fetid discharge, and epistaxis. (Pozzi, Schneider.) In the further course of the affection the bones become necrosed, the eyeball is invaded, the soft parts become gangrenous, and the mouth, gums, and superior maxilla are attacked, and perhaps denuded—the latter conditions, however, only occurring in extreme cases. The diagnosis is confessedly difficult, unless there be a clear history of the entrance of the insect, or some evidence of its life, in the discharges from the nose. To dislodge these insects, various expedients are recommended. Vapors of carbolic acid, sulphur, or iodine, forced into the cavities by means of compressed air, one nasal passage being held closed, and injections of saline solutions, or of those containing permanganate of potassium or carbolic acid, have all answered a good purpose. The inhalation of chloroform may be tried, or the insufflation of irritant snuffs may, by exciting the act of sneezing, be sufficient to cause their dislodgment. In extreme cases, the sinus must be trephined, to afford direct access to its interior. (Kohts.)

Foreign bodies may be formed within the frontal sinus: thus Bartholinus details instances in which he has seen, in the sinuses, earthy concretions similar to those which are sometimes found in the nose. Their treatment, if they give rise to any irritation, would be that of any other foreign body in this locality.

DISEASES OF THE ETHMOIDAL CELLS.

Owing to the direct continuity of the mucous membrane of the nose with that lining the cells of the sphenoid bone, all those processes which affect the former may likewise exert their influence upon the latter. Catarrhal inflammations, inflammatory thickenings, polypoid excrescences, and even, according to Virchow, osteitis and caries, with perforation of the base of the skull, may thus find their seat within the walls of this cavity. Diphtheritic ulceration of its mucous membrane has been reported. Chronic inflammation of the cells is, if we may credit Michel, the most frequent cause of so-called *ozæna*.

¹ See *Med. Times and Gazette*, January 30 and February 6, 1875, and *Indian Med. Gaz.*, August 18, 1874.

DISEASES OF THE ANTRUM OF HIGHMORE.

The mucous membrane which lines the interior of the cavity of the antrum, being but a direct continuation of the nasal or Schneiderian membrane, is liable, though not to the same degree as the latter, to develop inflammatory conditions, which are the result of a direct extension of the process by continuity of tissue from the nasal passage, and the converse is likewise true.¹ In many cases, the primary evidences of the antral affection may be detected in the nasal passage, by means of an anterior or posterior rhinoscopic examination; and as the resulting inflammation, swelling, and displacement of the nasal parts may be great in either case, and well calculated to deceive, a brief consideration of the commoner diseases of the antrum which occur in connection with those of the nose, is desirable at this point.

INFLAMMATION AND ABSCESS are the affections most frequently met with. Any extension of a severe catarrhal, syphilitic, or, more rarely, herpetic or variolous inflammation of the nasal mucous membrane, is an efficient factor in producing a like condition of that of the antrum—one which varies both in its degree, extension, and rapidity of development, as well as in the amount and character of the attendant secretion, which may be either mucous or muco-purulent. Salter has called attention to the peculiar circumstance which here gives importance to this altered and more abundant secretion, and to the disease; viz., that it may be confined within the sinus by means of the swelling and turgescence of the mucous membrane around its orifice, and that thus, from a mere anatomical arrangement, a catarrhal inflammation, spending itself by superficial suppuration, may lead to the formation of a shut, expanding sac, in many respects equivalent to a deep-seated abscess, though by no means identical with that condition either in pathological history or absolute anatomy. Aside from the above causes, affections of the teeth—dental caries, or alveolar abscess, in some stage, associated with disease of the teeth—are by far the commonest factors in the production of the disease. The peculiar anatomical relation which the antrum bears to the teeth is well known; it varies greatly, as regards both the extension of the antrum over the fangs of many or few teeth, and the degree in which these fangs approach or pierce the floor of the sinus. (Salter.) Other causes only occasionally exist; thus a blow upon the cheek has been known to excite acute inflammation within the antrum, and it has developed in the infant from injuries received during labor.² A case of abscess depending upon the presence of polypi within the antrum, is reported by Watson. Another, in which the cause was a bony tumor lying loose within the cavity, will be found in the *Edinburgh Medical Review*, October, 1867; and, finally, necrosis of the alveolar ridge, the presence of a tooth thrust into the cavity in endeavoring to extract it, and that of various other foreign bodies, introduced by violence, may all act as exciting causes of inflammation and suppuration.³ The tendency of the inflammatory process arising from any of these causes, to extend to or involve the nasal passage, has been alluded to. The physical signs of inflammation and pus-formation in the cavity of the antrum, vary necessarily in degree, and differ according to the exciting cause. Much depends, in regard to their severity, upon whether there be an outlet for the discharge of the pus, either through the natural opening of the

¹ Wolfram (On the treatment of catarrh of the antrum), *Berlin klin. Wochenschr.*, No. 6. 1879.

² Druitt, *Surgeon's Vade Mecum*, p. 431.

³ See, also, Weichselbaum (On phlegmonous inflammation of the accessory cavities of the nose), *Med. Jahrbuch*, Heft. ii. 1881.

cavity into the nasal passage, or, in rarer instances, through the socket of some tooth that has been removed, or fistulous passage that has been made; or whether, no ready outlet presenting itself, and the natural one being closed by the swelling of the tissues about it, the pus is pent up, a confined abscess resulting. In the first class of cases, the only indication that the process of suppuration is proceeding within the antrum, aside from the probably inflamed and swollen appearance of the nasal passage, may be the occasional discharge of quantities of offensive pus into the nose—especially when the head is held in certain positions—and the ozænic smell; and the cause will be found, in many cases, as has been stated, to be a decayed tooth, one fang of which, perhaps, protrudes through the floor of the cavity. An examination with the nasal speculum may disclose the fact that pus trickles into the middle meatus of the nose, and the diagnosis is thus confirmed. If a decayed and tender tooth be determined upon as the cause, it may be extracted; and through the passage thus made, and enlarged, if necessary, by means of a drill, the cavity of the antrum may be thoroughly washed out with disinfectant solutions. This will, in all probability, be all that is necessary to effect a cure. Should, however, discharge persist, a thorough exploration of the whole antrum, with scoop and probe, must be made through the perforation, in order to detect the foreign body, necrosed bone, fragment of tooth, or the like, which lies at the root of the matter and keeps up the discharge.

If, on the other hand, the matter is confined within the antrum—if abscess, in other words, result—the symptoms are marked and painful. As a class, these do not vary from the symptoms attendant upon like collections of matter within resistant walls in other parts of the body, though certain signs are, in this instance, incident to its particular locality. Thus, the expansion of the whole jaw; the elevation of the malar bone, with its fossa full and prominent; the apparent elongation of the molar teeth upon the affected side; the convexity of the normally concave hard palate; and the swelling of all the soft parts of the nasal passage, as shown in both anterior and posterior rhinoscopic examination, bespeak beyond doubt the true nature and exact situation of the disease. If relief be delayed, the eyeball may be displaced, and amaurosis—consequent upon periosteal inflammation extending into the orbit and involving the sheath of the optic nerve—may occur. The ultimate result, if nature be unaided by the surgeon, will vary much. Occasionally the abscess bursts into the nose, or the pus finds its way out, by burrowing alongside the fang of some tooth, into the mouth. More rarely it perforates the cheek or the floor of the orbit, and passes into the lower eyelid. Before, however, these latter accidents happen, fluctuation will usually be distinctly perceptible at some point upon the anterior surface, or in the hard palate, and the appropriate means of relief will be thereby suggested. If doubt still exist—if some portion of the bony walls be not so thin but that it yields on pressure, and gives to the finger the sensation of dry, tightly-stretched parchment—the use of a small trocar will serve to draw off enough fluid, usually no thicker than ordinary pus, and sometimes serous, to ascertain the nature of the swelling; and can do no injury to a solid growth if such be the true character of the expansion. Diagnosis is only difficult where the distension of the sinus goes on for years, as it sometimes does, slowly and painlessly, and with so little local disturbance that the idea of an abscess is not suggested; and in those rare instances in which abscess is complicated by the presence of a tumor within the antrum. Both classes of cases, and the errors in treatment to which a faulty diagnosis may lead, are illustrated by instances in Watson's work,¹ and are alluded to by other authors.

¹ Op. cit., p. 162.

Treatment.—Before the abscess has formed, when it is as yet only imminent, the inflammatory process may probably be arrested by removing some carious or tender tooth, which a skilful dental examination has shown to be its probable exciting cause. The first permanent molar, as a rule, is the one indicated, though the removal of several teeth may be necessary. When pus has already accumulated and no outlet exists, a free opening for its evacuation becomes necessary, and the method consists in the removal of a tooth and the perforation of the antrum at its base. Hunter¹ long since clearly sketched out this and the other surgical steps required:—"The first part of the cure, as well as that of all other abscesses, is to make an opening, but not in the part where it threatens to point, for that would generally be through the skin of the cheek. If the disease is known early, before it has caused the destruction of the fore part of the bone, there are two ways of opening the abscess: one by perforating the partition between the antrum and the nose, which may be done; and the other by drawing the first or second grinder of that side, and perforating the partition between the roots of the alveolar process and the antrum, so that the matter may be discharged for the future that way. But if the fore part of the bone has been destroyed, an opening may be made on the inside of the lip, where the abscess most probably will be felt; but this will be more apt than the other perforation to heal, and thereby may occasion a new accumulation, which is to be avoided if possible by putting in practice all the common methods of preventing openings from healing or closing up; but this practice will rather prove troublesome, therefore the drawing of the tooth is to be preferred because it is not so liable to this objection."

The opening having been made as thus described, it will usually need to be enlarged by the careful use of a large trocar, and the floor of the antrum may then be broken up sufficiently to afford a free opening for the discharge of the pus. A careful examination with the probe will now have to be made to detect the possible presence of any foreign substance, or of necrosed bone, and, if such be discovered, it must be removed, even, if necessary, by still further enlarging the opening. In conducting this examination, the thoroughness of which is important, the fact that the cavity of the antrum is occasionally divided by partial septa of bone projecting from its walls, as shown by Giraldès,² must not be forgotten, for in such an instance a foreign body might lie concealed in some circumscribed region of the sinus, and could only be removed by a curved scoop and by breaking down the partitions. The subsequent treatment will consist in securing thorough cleanliness by the daily free use of disinfectant and stimulating solutions—carbolic acid, permanganate of potassium, sulphate of zinc, alum, nitrate of silver (gr. ij-3j) and the like—until the discharge becomes healthy in its character, and loses its fetid smell. The opening made may be kept patent by the use of a silver or leaden style, secured in position by fastening it with wire to the neighboring teeth; or a small silver drainage tube may be used, secured in the same way. Salter has contrived an ingenious apparatus to effect the same purpose.³

A few points remain to be considered. Should it for any reason be desirable or necessary to open into the antrum at some point other than through the alveolar ridge, experience has shown that it is preferable to do so at the lower part of the canine fossa, the trocar being directed backwards and a little outwards. In cases where, on account of the swelling of the parts, the

¹ Practical Treatise on Diseases of the Teeth. London, 1771.

² Des Maladies du Sinus maxillaire. Paris, 1851.

³ Holmes's System of Surgery, 3d ed., vol. ii. p. 468.

patient's mouth cannot be opened sufficiently to allow of the extraction of a tooth and perforation of the alveolar ridge, the opening may best be made through the canine fossa, as in the former instance, for the sake of temporary relief, and when the acute symptoms have passed off, the operation may be completed by perforating in the usual way through a tooth cavity into the antrum. The latter operation again is indicated in those instances, rare though they be, where a troublesome, fistulous opening remains as the result of the perforation of an abscess through the cheek or lower eyelid. Enlargement of the sinus, for the purposes of drainage, cannot be undertaken for fear of increasing rather than diminishing the deformity, and its locality prevents its serving the same purpose as a more dependent opening, which should in all instances be made to secure thorough drainage.

EFFUSIONS OF BLOOD may occasionally occur in the antrum, either as the result of direct violence, or in consequence of nasal hemorrhage, the blood passing into the antrum through the nasal opening. Suppuration may thus be caused. The *treatment* would be that of ordinary abscess of the antrum.

TUMORS.—Morbid growths of varied nature are extremely liable to originate within the antrum, or less frequently from the alveolar border of the superior maxilla, and involve, in their too often rapid and destructive course, not only the whole cavity of the antrum, but, by gradual extension and breaking down of the thin bony partitions, the cavities of both nose and orbit; the resultant displacement and deformity are excessive. Weber, in a careful and instructive study of 307 cases of tumor of the antrum, has shown their relative frequency to be as follows: carcinoma, 133; sarcoma, 84; osteoma, 32; cystoma, 20; fibroma, 17; enchondroma, 8; gelatinoid polypus, 7; melanotic sarcoma and carcinoma, 5; and, finally, angioma, 1; but he remarks that carcinoma occurs too frequently in the list, doubtless from its having been frequently confounded with medullary sarcoma. He believes that the latter embraces rather more than one-third, and carcinoma less than one-third, of all morbid growths of the superior maxillary bone.

These tumors, their differential diagnosis, and the operations necessary for their removal, are fully considered in other articles.

DISEASES OF THE SKIN AND SUBCUTANEOUS TISSUES OF THE NOSE.

A number and variety of affections may develop primarily in the integument covering the nasal organ, or may involve it by a process of extension from neighboring parts; of these the commonest are herpes, acne, eczema, nævus, syphilis, lupus, and epithelioma; more rarely, rhino-scleroma and malignant pustule. Gangrene and frost-bite also may claim the attention of the surgeon. These affections are elsewhere considered.¹

¹ See Vol. I., pages 228, 745, 787, and Vol. III. pages 54 *et seq.*

Note to page 767.—Several very valuable contributions to our knowledge of the pathology of hay fever, which the reader should by all means consult, are the following: J. O. Roe, *The Pathology and Radical Cure of Hay Fever or Hay Asthma* (New York Med. Journal, May 3, 1884); *Ibid.*, May 12 and 19, 1883: Harrison Allen, *Amer. Journ. Med. Sciences*, Jan. 1884; C. E. Sajous, *Hay Fever and its Successful Treatment* (Trans. Amer. Laryngological Association, 1884. Abstract, with discussion and remarks by Drs. Shurly, Bosworth, Mackenzie, Robinson, and Johnson, *Medical News*, May 24, 1884). The reader should consult also Hack, *Ueber eine operative Radicalbehandlung bestimmter Formen von Migräne, Asthma, Heufieber, sowie zahlreicher verwandter Erscheinungen*. Wiesbaden, 1884. These contributions to the subject of hay fever have appeared since the above article was written. They throw much new light upon the obscure and disputed question of causation, and should certainly be read in connection with what is said in the text.

[APPENDIX.

RHINOPLASTIC OPERATIONS.

(By the Editor.)

RHINOPLASTIC operations, or operations designed to accomplish the partial or complete restoration of a nose, may be required to correct a congenital deformity, to remedy the effects of injury, or to repair the ravages occasioned by ulceration, with or without necrosis or caries, by lupus, by constitutional syphilis, etc. It is an invariable rule in nasal surgery that no operation of this kind shall be undertaken until the process of destruction by which it is rendered necessary has been entirely and definitively checked.

Rhinoplastic operations may be divided into those designed to repair a nose which has been only partially lost, and those intended to remedy complete destruction of the organ.

I. OPERATIONS FOR PARTIAL RESTORATION OF THE NOSE.

REPAIR OF COLUMNA AND SEPTUM.—Should the loss of tissue be limited to the *columna nasi* and *septum*, a new columna may be conveniently formed from the upper lip, by making an incision on either side of the median line, and through the whole thickness of the part, thus separating a portion about one-third of an inch in width, and of a length equal to the depth of the lip; this strip is then turned upwards, and its end, having been suitably trimmed, is adapted to the tip of the nose, which must be freshened for the purpose, and is secured in its new position by the twisted or shotted suture. The labial mucous membrane which is thus turned outwards, gradually loses its normal character and becomes assimilated to skin. The sides of the lip are approximated with harelip pins and interrupted sutures, and a few narrow strips of plaster are so adjusted as to support the transplanted portion until it becomes firmly adherent in its new position. The dimensions of the newly-made nostrils must be maintained by occasionally introducing into each a silver or gutta-percha tube.

DEFICIENCY OF ONE OF THE ALÆ may be repaired, if the loss of tissue be but slight, by taking a flap from the upper part of the nose itself, and attaching it with numerous points of the interrupted suture to the previously freshened edges of the gap. If the deficiency be greater, it will be necessary to take a flap from the cheek or forehead, the former plan being, I think, the better. The cheek-tissues are very vascular, and a flap large enough to replace almost half the nose can be readily obtained, and by curving the ends of the incisions can be slid into place, without any necessity of twisting the pedicle upon itself, as must be done when the flap is taken from the forehead. If the latter plan be adopted, to prevent sloughing of the pedicle, a groove should be cut on the dorsum of the nose for its reception. When union is completed, the pedicle may be raised and cut away, and the groove then closed again with sutures.

UNDUE SHORTNESS OF THE NOSE is sometimes the source of much annoyance, and may be remedied by the plan adopted by Prof. Weir, of New York, which consists in cutting across the nose in a transverse direction, drawing down the tip to the desired position, and filling the wedge-shaped gap which results by transplanting flaps from the cheeks.

Should the patient seek relief on account of the opposite condition—too great *length of nose*—it would probably be sufficient to remove a transverse wedge from the elongated tip of the organ, and close the wound with sutures.

OPERATION FOR DEPRESSED NOSE.—Disease of the nasal bones and cartilages may cause the organ to have a flat and sunken appearance, without there being any external ulceration. The late Sir William Fergusson, in a case of this kind, succeeded in remedying the deformity by a modification of the procedure originally suggested by Dieffenbach. Introducing a narrow knife within the nostrils, he separated the soft tissues from the underlying bones, and then brought the whole nose forward by passing long, steel-pointed, silver needles through its base from cheek to cheek, and then twisting them over strips of perforated leather. A new columna was afterwards formed in the ordinary manner.

FISTULOUS OPENINGS through the bones of the nose are occasionally met with, as the result of necrosis following scarlet fever, etc. The treatment consists in freshening the edges of the orifice, and adapting a flap taken from either cheek or forehead as may be found most convenient.

II. OPERATIONS FOR RESTORATION OF THE WHOLE NOSE.

Several methods are employed for restoring the entire nose, when this is necessary, those which are best known being respectively called the *Taliacotian* and the *Indian* operation.

THE TALIACOTIAN METHOD has received its name from Tagliacozzi, or Taliacotius, an eminent Italian surgeon of the sixteenth century, who published an account of his operation, with numerous illustrations, in 1597.¹ It is perhaps hardly necessary to say that the Hudibrastic notion that Taliacotius fashioned noses for his patients from the nates of persons hired for the purpose, is unfounded, having, according to Dr. Ferriar, originated in a malicious jest of Van Helmont. The part from which the Taliacotian nose was really derived, was the upper, and usually the left, arm of the patient himself. A flap of skin and connective tissue of sufficient size is, in this operation, first marked out on the upper arm and partially detached, and is left in this condition for about two weeks, in order that it may become vascular and thickened by the process of granulation. At the end of this time the stump of the original nose is pared, and the flap then reduced to proper shape, and attached by numerous stitches in its intended position, the arm being brought up to the head and fixed by a complicated arrangement of slings and bandages. After about ten days more, when the new nose is supposed to be firmly adherent, its connections with the arm are severed, and any needful trimming of the new organ is effected. Finally a columna is made from the upper lip.

This operation has been varied by Warren and others, by taking the flap

¹ De Curtorum Chirurgia per Insitionem Libri Duo. Venetiis, 1597.

from the forearm, and by diminishing the time during which the head and arm are kept in contact; but even with these modifications, it is so tedious and irksome that it is seldom employed at the present day, though it has been occasionally adopted, and with success, as by Sir William MacCormac, and by Dr. Stokes, of Dublin. In order to provide a bony support for the new nose, Dr. Hardie, of Manchester, in the case of a young girl, transplanted the ungual phalanx of one of her fingers, keeping his patient's arm fastened up to her face for no less than *three months*.

THE INDIAN METHOD, which is that now commonly adopted, was introduced into England by Mr. Carpue, in 1816.¹ By this method the nose is made from a flap taken from the forehead, supplemented if necessary by a columna derived from the upper lip. As ordinarily performed, the operation may be divided into three stages.

In the *first stage*, a flap of proper size and shape is cut from the skin of the forehead, and attached in the position which it is meant to occupy. A piece of thin gutta-percha or card-board is first modelled to the form and dimensions of the wished-for organ, and is then flattened out and laid upon the forehead as a guide for the future incisions. The flap may be taken from the centre of the forehead, or from either side, as may be thought most convenient. As the flap is sure to shrink after it is detached, it is a good rule to allow a margin of one-fourth of an inch on all sides of the pattern, and the lines of incision should be carefully marked with a dark crayon, or with tincture of iodine.

The error is sometimes committed of making the flap needlessly large, and I have known of cases in which the new nose has by its prodigious bulk been a source of quite as much mortification to the patient as his previous lack. Hence the importance of carefully outlining the form of the needed part, and of not allowing more than the quarter-inch margin which has been directed. Should the patient have an unusually high forehead, the central portion of the flap may be prolonged in order to furnish a columna, but under other circumstances this part of the operation is better left for a subsequent occasion. I may add that Prof. Bennett, of Dublin, advises against the formation of a columna altogether, finding that the contraction of the deep surface of the flap leaves an orifice none too large for the admission of air, and that the overhanging of the middle lobe of the flap prevents any deformity.

In raising the frontal flap the incision is begun at the root, which is made long, so that its circulation may not be interfered with when it is twisted; the incision is usually prolonged further on one side than on the other, so that the root may be twisted more readily. All the soft tissues of the forehead should be embraced in the flap, and it has even been recommended that the periosteum should be likewise included, in hope that by its osteogenetic power bone might be developed in the transplanted tissue. Such a result, however, would not be very likely to ensue, nor, if it did occur, would it be of much benefit to the patient, while by depriving the frontal bone of its periosteum, some risk is entailed of necrosis. When the flap has been formed, it is temporarily replaced over a piece of wet lint, while the stump of the old nose is prepared for its reception. This is done by freshening its edges, dissecting up the skin in such a way as to make a groove to receive the flap, which should itself have its edges bevelled so as to provide two raw surfaces. All bleeding having been arrested—if possible without using any

¹ Account of Operations for restoring a Lost Nose from the Integuments of the Forehead, etc. London, 1816.

ligatures—the flap is lightly twisted upon its root and adjusted in its new position, being secured with numerous points of the interrupted or shotted suture, or with the ingenious “tongue-and-groove suture” recommended for the purpose by the late Prof. Joseph Pancoast, of Philadelphia, who had great success in rhinoplastic operations. The flap should be supported by gently introducing below it a plug of oiled lint, or two small plugs, one on either side of the columna, if there be one, and a fold of oiled lint may be lightly laid over the part, to assist in preserving its temperature. The wound on the forehead may be partly closed with harelip pins and adhesive strips, but must be mostly left to heal by granulation. The patient, after the operation, should be put to bed in a warm room; the dressings should not be disturbed for several days, when it will probably be necessary to remove the plug and introduce a new one; the sutures should remain until firm union has taken place.

The *second stage* of the Indian method consists in forming a columna from the upper lip, if one has not already been made from the forehead. This may be done, in the way heretofore described, either at the time of, or two or three weeks after, the former operation. As has been mentioned, Prof. Bennett thinks it better to dispense with the columna altogether.

The *third and final stage* consists in separating the root of the frontal flap, which should not be done until at least a month after the first operation. A narrow bistoury is thrust beneath the pedicle, and made to cut its way upwards, removing a wedge-shaped portion so as to give a smooth bridge to the nose; or Fergusson's plan may be adopted, the root of the new nose itself being cut into a wedge, and laid into a groove made for it in the forehead.

The size of the opening or openings left for the admission of air, must be maintained by the patient's wearing, for several months, a tube or tubes of silver or gutta-percha. The results of the Indian operation are commonly quite satisfactory, though failure may ensue from the flap sloughing, or from a recurrence of the disease which rendered the operation necessary. In one of Liston's cases, secondary hemorrhage followed on the ninth day, and death even has resulted, in the practice of a no less distinguished operator than Dieffenbach.

SYME'S METHOD.—This mode of operating, which was introduced by the late Prof. Syme, of Edinburgh, aims to utilize the tissues of the cheeks, from which flaps are taken, and united in the median line by sutures, while their outer edges are attached to raw surfaces which have been previously prepared at a suitable distance from the nostrils. The nose made by this method is apt to be rather flat, to prevent which it might be well to keep it pressed forward, until the occurrence of union, by fastening the sides together with steel-pointed silver needles, in the way already described in speaking of the treatment of depressed nose.

WOOD'S METHOD.—Prof. John Wood, of King's College, London, following in the same lines as in his ingenious operation for extroverted bladder, employs an inverted flap, taken from the upper lip and elongated by separating its mucous from its cutaneous surface, from the root of the flap to, but not through, its free border, and then covers this with lateral flaps derived from the cheeks.

OLLIER'S METHOD.—Prof. Ollier, of Lyons, likewise employs an inverted flap, but taken from the forehead and made to include the periosteum, and covers it with side flaps taken by preference from the stump of the nose.

Finally, I feel bound to say that, in some cases, it may be better not to attempt any rhinoplastic operation, but to be satisfied with the adaptation of an artificial nose, which may be supported by a spectacle-frame, and kept in place by the pressure of a light spring within the nostrils. The best material for the manufacture of artificial noses, is said by Prof. N. W. Kingsley, of New York, who has been quite successful in this branch of prothetic surgery, to be the substance which is known to dentists as "rose pearl," and which is, I believe, a preparation of collodion.]

INJURIES AND DISEASES OF THE FACE, CHEEKS, AND LIPS.

BY

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WOUNDS OF THE CHEEKS.

THESE are often attended with considerable hemorrhage, from division of branches of the facial and transverse facial arteries. There is, for the most part, no difficulty in securing these vessels by torsion or by ligature. When the wounds are deep and extensive, they should be accurately closed by fine sutures, as in this situation agglutinative plasters are entirely unreliable. When the wound involves the duct of Steno, there is danger that it will be followed by salivary fistula. This is to be guarded against by extending the wound freely into the buccal cavity, and by special care in the accurate adjustment of the edges of the divided skin. When the facial nerve or its branches are divided, the muscles to which they are distributed will be paralyzed. It is important, in such cases, that the divided ends of the nerve should be brought in contact, and secured by fine sutures. If a twig of the trifacial nerve should be included between the edges of the wound, it may become the seat of neuralgic pains, and in such cases the affected portion of the cicatrix should be excised.

BADLY LACERATED OR CONTUSED WOUNDS, AND GUNSHOT WOUNDS, of the face, may lead to sloughing with considerable loss of substance, followed by cicatricial contractions which distort the features and cause morbid adhesions of the lips and cheeks to the jaw-bones. Great care should be taken, during the treatment of such wounds, to guard against these distortions and adhesions. In many cases, these unpleasant effects cannot be altogether prevented, but in most instances they may be subsequently remedied, in part at least, by plastic operations. The face is often much disfigured by a deeply depressed cicatrix, occasioned by adhesion of the skin to the periosteum or bone. I have succeeded in relieving this disfigurement by the very ingenious operation introduced by Mr. Wm. Adams, of London.¹ This operation consists in the free subcutaneous division of the constricting band, followed by the elevation of the cicatrix above the level of the surrounding integument, this position being maintained for three days by means of two harelip pins crossing each other at right angles.

POISONED WOUNDS of the face are not uncommon, such as are inflicted by the stings of bees, wasps, and hornets, and by the bites of spiders. The

¹ British Med. Journal, April 29, 1876.

burning heat and pain, and the other inflammatory symptoms, are promptly relieved by the application of a strong solution of bicarbonate of sodium.

Severe inflammatory swellings of the face are also occasioned by contact with poison-ivy. Among the remedies which have been highly recommended for the relief of these symptoms are saturated solutions of sulphite and hypsulphite of sodium; liquor sodæ chlorinatæ of full strength, or diluted with from three to six parts of water; and bromine dissolved in olive oil, gtt. x-xx to f3j.¹

FACIAL PARALYSIS.

The facial nerve may be paralyzed in consequence of a wound dividing its trunk, or from pressure in any part of its course, within or without the cranium. Paralysis may result from exposure to a draft of cold air, and from other causes, some of which are quite obscure. The face is drawn towards the opposite side, the mouth cannot be perfectly closed, the eyelids of the affected side remain widely open, and the eyeball is exposed to injury. When the paralysis is the result of division of the nerve, the divided ends may be united by suture. When it occurs from other causes, benefit may sometimes be derived from the use of electricity, and from the administration of strychnia, either by the mouth or hypodermically.

SALIVARY FISTULA.

This may be the result of wounds, burns, or sloughing or phagedenic ulceration, involving the duct of Steno. The outflow of saliva is an occasion of much annoyance to the patient, and it sometimes taxes the ingenuity of the surgeon to effect a cure. The main indication for treatment is to establish a free communication between the duct and the interior of the buccal cavity, and to close the external orifice of the fistula. This object may sometimes be accomplished by introducing a seton or tent through the fistula into the cavity of the mouth, and wearing it until a sufficiently large internal orifice has become established, and then closing the external orifice, either by the application of the actual cautery or by paring its edges and drawing them together with sutures. In obstinate cases, after establishing the internal opening, the external orifice may be closed by a plastic operation.

Desault gives minute directions for the cure of salivary fistula by seton.²

In cases of unusual difficulty, the fistulous orifice, with the portion of the duct communicating with it, may be dissected from the surrounding parts and introverted into the cavity of the mouth, where it may be fixed with silver wire sutures. Operations of this kind have been performed by Langenbeck, Van Buren, J. R. Wood, and Erskine Mason.³ Dr. H. H. Smith, in his work on Operative Surgery, describes an operation devised by the late Dr. Horner, who punched a hole through the cheek, making a free opening into the buccal cavity, and then closed the external wound.

Rodolfi succeeded in closing a salivary fistula by painting the surface with collodion.⁴

¹ See Med. Record, July 12, 1879, p. 46; Aug. 2, p. 117; Sept. 20, p. 284; Apr. 20, 1878, p. 320; and July 1, 1873, p. 313.

² *Euvres Chirurgicales de Desault*, par Bichat, tome ii. p. 221.

³ See Med. Record, Aug. 7, 1880, p. 163.

⁴ Gazz. Med. Ital. Lombard., t. iii. 1854.

FACIAL NEURALGIA OR TIC DOULOUREUX.

This is an exceedingly painful affection of the nerves of the face, chiefly affecting the branches of the fifth pair. It may be the result of traumatic lesions, or it may occur from malarial exposure, or from a variety of constitutional or local causes. Its most common cause is direct irritation of the dental nerves, but it may be the result of reflex irritation originating in parts more or less remote. The pain often occurs in paroxysms of frightful severity, aggravated even by the slightest touch or motion of the affected parts. During the intervals between the paroxysms, the remissions are often quite incomplete, and the sufferings of the patient are so severe and persistent, as to render life an almost intolerable burden.

Treatment.—Special attention should be paid to the causal indication. When the neuralgic pains are the result of reflex irritation, the primary cause should be carefully investigated, and appropriate remedies should be employed to remove it, or to counteract its agency.

When the neuralgia is the result of direct irritation of the branches of the fifth pair of nerves, relief may sometimes be afforded by powerful revulsion, as by the application of the moxa or the actual cautery. Bartholow cured several cases by injecting chloroform deeply into the tissues in the vicinity of the nerve involved in the disease. He injected half a drachm, passing the needle from the border of the upper lip to the vicinity of the infraorbital foramen.¹ Dr. J. B. Mattison, of Chester, N. J., adopted the same treatment, injecting 20 minims of chloroform. There was severe pain at first, followed by complete relief.²

Dr. Henry Hunt published a treatise on tic douloureux, in London, in 1844. He entered largely into the etiology and the medical treatment of the disease. He regarded it as often due to functional disorder or organic disease of the digestive organs, atonic dyspepsia being one of its common causes. When the tongue was heavily furred, and the urine turbid, he recommended an emetic at the beginning of the treatment, followed by a mercurial cathartic. After this preparatory treatment, he often gave with advantage Fowler's solution, beginning with four minims, and gradually increasing the dose to ten or twelve minims three times a day. When this disagreed with the patient, he gave two or three minims of Scheele's prussic acid, and small doses of nitrate of potassium, with three or four grains of James's powder at bedtime. He attached much importance to the use of warm clothing, and to moderate exercise in the open air, avoiding fatigue, especially just before or after eating. For the relief of the severe paroxysms of pain which continued after the removal of visceral congestion, he prescribed opium, belladonna, camphor, and other narcotics. Among these he found belladonna the most efficient. In severe cases he gave one grain of the extract hourly, until three grains had been given. He then suspended the remedy and watched the case. After the first strong impression, he usually found that smaller doses sufficed. He always avoided the use of anodynes while there were symptoms of visceral congestion. As a local application affording temporary relief, Hunt recommended an ointment composed of one grain of aconitine and one ounce of cerate, rubbed upon the part for two or three minutes at a time, and repeated twice a day. Dr. Hunt had seen excellent results from the removal of neuralgic patients from low and damp places to a high and dry locality.

When neuralgia is evidently the result of exposure to malaria, and when

¹ Med. and Surg. Reporter, No. 871.

² Med. Record, May 1, 1874, p. 227.

the paroxysms recur at regular intervals, it may sometimes be cured by large doses of quinine. The internal use of aconitine has been highly recommended in the treatment of neuralgia. It was brought to the attention of the profession by Dr. Gubler, who published an article on the subject in 1877.¹ Prof. Gubler used Hottot's preparation of nitrate of aconitine, commencing with doses of $\frac{1}{160}$ grain and increasing them when necessary to $\frac{1}{12}$ grain. He regarded heart-disease as contraindicating the drug. Dr. E. C. Seguin² has published a report made to the New York Therapeutical Society, giving his experience in the use of aconitine in facial neuralgia. He has obtained good results from the use of this remedy. The internal use of salicylate of sodium in doses of from 1 to 5 grammes daily has been recommended by Dr. Descroizelles.³ Dr. Howard Pinkney reports a case of facial neuralgia of two years' standing, cured by the use of sulphite of sodium, in scruple doses four times a day.⁴ Relief has been afforded by the use of tonga.⁵ Drs. Rockwell, Beard, and Neftel report successful results from the employment of electricity.⁶ Cases are said to have been cured by hypodermic injections of a two-per-cent. solution of carbolic acid.⁷

Lennox Brown highly recommends the external application of a mixture of equal parts of chloral hydrate and camphor.⁸ Dr. J. Mason Warren, in his *Surgical Observations*, relates cases in which great relief was afforded by the persistent use of hypodermic injections of morphia. In some of these cases, a permanent cure seems to have been effected. An ointment of veratrine, 10 grs. to 3j, has been used as an external application with marked advantage, being rubbed over the painful parts at intervals of two or three hours.

The division of the affected branches of the fifth pair of nerves has been resorted to in a large number of cases. In some of these, complete relief has followed the operation, but in most instances the pain has returned after a longer or shorter interval. The mere division of the nerve generally fails to afford a permanent cure. Excision of a considerable portion of the nerve yields better results, but in many cases the cure is not permanent. The operation of neurectomy is often unsuccessful, because the nerve is not excised sufficiently near to its origin. Dr. Carnochan, of New York, is entitled to the credit of having first directed the attention of surgeons to this important fact in the case of the superior maxillary nerve, and of having devised an operation for the excision of the nerve in the immediate vicinity of the foramen rotundum. He performed this operation for the first time on the 16th of October, 1856.⁹ He raised a triangular flap, bounded by two incisions extending downward and outward from the inner canthus, and downward and inward from the outer canthus, meeting at a point half an inch in a vertical line below the infra-orbital foramen. From the apex of this triangular flap, a sharp-pointed straight bistoury was next thrust through the cheek into the cavity of the mouth, and an incision was carried downward and inward through the upper lip, dividing it completely to a point midway between the median line and the labial commissure. The upper triangular flap

¹ *Gaz. Hebdom.*, 9 Fév. 1877; *Am. Journ. Med. Sci.*, April, 1877; *Practitioner*, Aug. 1877.

² *New York Med. Journal*, Dec. 1878. He has published another paper on the subject in the *Archives of Medicine*, Aug. 1881, p. 89. See also *Med.-chir. Rundschau*, Aug. 1878; *Med. Record*, Dec. 28, 1878, p. 512.

³ *Progrès Médical*, 21 Juillet, 1877; *Med. Record*, Sept. 1, 1877, p. 558.

⁴ *Med. Record*, Dec. 1, 1868, p. 433.

⁵ *Lancet*, March 6, 1880; *Med. Record*, May 8, 1880, p. 513.

⁶ *Med. Record*, March 15, 1869, p. 28; June 15, 1869, p. 169; Feb. 1870, p. 97.

⁷ *Allg. med. Cent.-Zeitung*, 6 Sept. 1876; *Med. Record*, Nov. 18, 1876, p. 750.

⁸ *Brit. Med. Journal*; *Med. Record*, Aug. 1, 1874, p. 404.

⁹ *American Journal of the Medical Sciences*, January, 1858.

was dissected upward, and the two lower flaps were turned, one inward toward the nose, and the other outward over the malar bone. The anterior surface of the superior maxillary bone, and the lower margin of the orbit, were thus exposed to view. The crown of a trephine, three-quarters of an inch in diameter, was then applied to the anterior wall of the antrum, just below the infra-orbital foramen, and a disk of bone was removed, exposing the cavity. The anterior portion of the trunk of the nerve was now exposed. The infra-orbital canal was next laid open with a delicate chisel and a hammer, and the posterior wall of the antrum dealt with in like manner, exposing the nerve in the sphenomaxillary fossa. The posterior dental nerves were divided, as also the branches going to Meckel's ganglion, and the branch running up to the orbit. Lastly, the trunk of the nerve was divided with blunt-pointed scissors, curved on the flat, close to the foramen rotundum. The hemorrhage was not profuse, and the edges of the wound were brought together with thirteen points of twisted suture. Fourteen months after the operation the patient was in good health, and was entirely free from neuralgic pain. Dr. Carnochan reported two other cases in which he had performed the same operation with results which were good, although a sufficiently long time had not elapsed to test the permanence of the cure.

Dr. Carnochan's operation has been repeated by a number of surgeons, with variable success. The operations of neurotomy and neurectomy have also been performed with more or less success on the ophthalmic and inferior dental branches of the fifth pair of nerves.¹

As a substitute for neurectomy, the operation of nerve-stretching has been resorted to with some measure of success in the treatment of facial neuralgia, as well as in that of other nervous disorders.²

BURNS OF THE LIPS AND CHEEKS.

These injuries are of frequent occurrence. They are very painful, and greatly interfere with the prehension of food. When they are deep, they are very apt to be followed by cicatricial contractions, which distort the features and greatly disfigure the patient. Special care is required to guard against such distortions. When the face is burned by the explosion of gunpowder, the grains of powder are often deeply imbedded in the skin; they should be carefully removed, one by one, while the patient is under the influence of an anæsthetic.

FROSTBITE.

The lips and cheeks may be injured by exposure to severe cold, and ulceration, or sloughing, may be the result. The sores may be treated by the

¹ See *Annals of Anatomy and Surgery of Brooklyn*, April and May, 1880; *Med. Record*, Nov. 1, 1871, p. 392; Jan. 2, 1872, p. 485; Aug. 18, 1877, p. 520; June 5, 1880, p. 620; Aug. 13, 1881, p. 187; Nov. 15, 1879, p. 468; *La France Médicale*, 16 Juin, 1877; *New York Med. Journal*, June, 1879; Ernst Burrow, *Mittheilungen aus der chirurgischen Privat-Klinik*, 1875-1877; *Transactions of Am. Med. Association*, 1880; J. M. Warren, *Surgical Observations*; *Med. and Surg. Reporter*, 1869; *Med. Record*, Aug. 16, 1869, p. 271; Oct. 1, 1869, pp. 345 and 346; Apr. 1, 1868, p. 60; Jan. 2, 1872, p. 485; Dec. 15, 1877, p. 792; June 19, 1880, p. 701; Oct. 23, 1880, p. 449; *Am. Jour. Med. Sciences*, 1868 and 1869; *Cincin. Lancet and Observer*, 1869; *Detroit Med. Journal*, Nov. 1877; *New England Journal of Medicine and Surgery*, vol. xii. p. 216; *New York Journal of Medicine*, Nov. 1856; *Transactions of King's County Med. Soc.*, 1877.

² See *Brit. Med. Jour.*, Oct. 18, 1879; *Med. News and Abstract*, Jan. 1880, p. 49; *Quarterly Epitome of Pract. Medicine and Surgery*, March, 1880, p. 86; *London Med. Record*; *Hosp. Gazette*; *Med. Record*, March 27, 1880, p. 346; July 24, 1880, p. 111; Aug. 14, 1880, pp. 172, 183; Jan. 15, 1881, p. 71; Jan. 22, 1881, p. 107; Aug. 13, 1881, p. 180; Aug. 27, 1881, p. 245.

application of a stimulating ointment made by the mixture of 3j or 3ij of oil of turpentine, or of Peruvian balsam, with 3j of vaseline. The healing process may be attended by cicatricial contraction, requiring the same treatment as that which is demanded when contraction attends the healing of a burn or other severe injury.

FACIAL ERYSIPELAS.

The integument of the face is peculiarly liable to erysipelatous inflammation. This may occur as a consequence of local injury, or it may be the result of constitutional causes. It may occur sporadically, or it may be endemic, as in the wards of a hospital. It is especially apt to occur where cleanliness and ventilation are neglected. It is apt to be communicated by foul sponges and other similar appliances. It may be simple or phlegmonous in its character. Its general course is the same as that of erysipelas in other parts of the body, but the prognosis is more unfavorable, as the inflammation is very apt to involve the brain and its membranes. The treatment should be prompt and active, to arrest the disease as early as possible. Laxatives and diaphoretics may be administered at the very beginning of the disease, followed by tonics, such as the sulphate of quinia, or the tincture of the sesquichloride of iron. As local applications, blisters may be applied to the surface, or the inflamed parts may be painted with tincture of iodine, or covered with cloths moistened with a solution of sulphate of iron, 3ij to Oj; or hypodermic injections may be made of a 2½ per-cent. solution of carbolic acid.

MALFORMATIONS AND DEFORMITIES OF THE CHEEKS AND LIPS.

MACROSTOMA.—This term is used to indicate a condition in which the opening between the lips is abnormally large, so as to constitute a marked deformity. The commissures of the lips may be extended outward and backward into the cheeks, on one or both sides, in a horizontal line, or obliquely upward or downward. The deformity may be congenital, or it may be the result of a wound imperfectly healed. It may be successfully treated by paring the edges of the fissure, and uniting them by sutures. In this way, the mouth may usually be restored to its normal size and shape.

MICROSTOMA.—This name indicates a deformed condition in which the labial orifice is abnormally small. It may be congenital, or it may be the result of cicatricial contraction, following a burn, sloughing, or phagedenic ulceration. In some cases, the opening of the lips is so much contracted as to interfere with the introduction of food into the mouth. The opening may be enlarged by making a horizontal incision on each side into the cheek, and by attaching the mucous membrane to the skin by a number of fine sutures. When the tissues are very much consolidated by cicatricial contraction, there will be difficulty in maintaining the opening, and it will be necessary to stretch the parts mechanically, and to maintain the dilatation for a long period. This dilatation may be effected by metallic arcs introduced into the angles of the mouth, after free incisions have been made, and drawn asunder by elastic bands passing around the back of the neck.

ATRESIA ORIS.—This is described by authors as a congenital defect, in which the anterior buccal orifice is entirely wanting. If such a malformation should be met with, it would be necessary to make a horizontal incision

into the cavity of the mouth, and to form a vermilion border for each of the newly constructed lips by uniting the mucous membrane with the skin.

DISTORTIONS OF THE MOUTH in various directions may be the result of cicatricial contraction from burns, or from other causes. The angles of the mouth may be drawn upward, or downward, or outward and backward; or the lips may be widely separated from each other, so that the mouth cannot be closed, and the saliva cannot be retained. Something may be done, during the process of cicatrization, to prevent these distortions, or to diminish their extent. The principal means to be employed for this purpose are the free application of caustic, methodical pressure by adhesive plasters and bandages—to repress the growth of exuberant granulations—and the stretching of the affected parts in the opposite direction to the threatened distortion. When a large granulating surface is exposed, benefit may often be derived from skin-grafting, inserting small pieces of very thin integument in the midst of the granulations, covering them with goldbeaters' skin, and maintaining close contact for several days by strips of adhesive plaster and bandages. When cicatrization has already taken place, and dense bands of inodular tissue have greatly distorted the buccal orifice, these bands should be freely divided through their whole breadth and depth by a number of parallel incisions, and the healing process should be retarded by keeping the affected parts upon the stretch, and by frequently repeated passive movements. Or, in appropriate cases, a single free and deep incision may be made through the cicatricial band, the margin of the lip may be at once brought into its proper position, and a flap of integument from the vicinity may be inserted, so as to fill up the chasm produced by the incision and by the reposition of the labial margin.

HYPERTROPHY OF THE LIPS.—This occurs sometimes as a congenital affection, or it may commence at a period subsequent to birth. It may involve either lip or both. When it exists to any considerable extent, it constitutes a very conspicuous deformity, and seriously interferes with the functions of the lips. It presents itself in two forms, partial and general. Partial hypertrophy, which affects chiefly the upper lip, involves the mucous membrane and the submucous cellular tissue, and is usually more prominent on either side than in the median line. It has been described by writers as *Double Lip*. It is cured by excising the hypertrophied parts and bringing together the edges of the wound with sutures. Dr. Agnew, in his work on Surgery,¹ gives a wood-cut of Double Lip. (Fig. 996.) General hypertrophy of the lip involves the skin and mucous membrane

Fig. 996.



Double lip. (After Agnew.)

¹ Principles and Practice of Surgery, vol. ii. p. 891.

with all the intervening tissues. It is treated by excision of a wedge-shaped segment of the lip, the base of the wedge corresponding with the vermilion border. An interesting case of this deformity, illustrated by wood-cuts, is described by Dr. Buck.¹

HARELIP.

Harelip is a congenital malformation of the upper lip, resulting from arrest of development, and presenting, in the more mature state, a continuance of that which is the normal condition in the earlier stages of embryonic development. It derives its name from its resemblance to the cleft which exists in the upper lip of the hare, the rabbit, and other allied animals. It consists of a fissure, usually extending through the whole thickness of the lip, from the nose to the vermilion border. There are several varieties, indicated by the names single and double, simple and complicated. The term single implies that there is but one fissure. The term double denotes that there are two. A simple harelip is one in which there is no concomitant malformation of the upper jaw or palate. A complicated harelip is one in which there is a deviation from the normal development of the jaw or palate, or in which the malformation involves both of these parts.

In a *single harelip*, the fissure is rarely situated exactly in the median line. In the large majority of cases it is on the left side, so that the right portion of the lip is broader than the left. In some cases the fissure involves only the lower portion of the lip, not extending up to the nose. In some cases the margins of the fissure are nearly parallel, and are almost in contact, while in other cases they are widely divergent towards the free border of the lip.

In *double harelip*, the two fissures are usually on the two sides of the median line, and the intermediate portion may be quite narrow, or may be of considerable breadth. It is usually broader towards the nose than towards the free margin of the lip. In many cases it does not extend as low as the free border of the lateral portions of the lip.

In *complicated harelip*, the malformation of the upper jaw may be twofold. There may be an advance of the median portions of the superior maxillary bones far beyond their ordinary position, these projecting portions being detached from the main body of the jaw, and constituting intermaxillary bones such as exist normally in some of the inferior animals. The middle incisor teeth are usually developed in these intermaxillary bones. Or, instead of a projection of the maxillary bones, there may be a fissure, single or double, extending through the alveolar portion of the jaw. The fissure may also involve the bony and soft palate. In many cases of complicated harelip, the abnormal prominence of the jaws and fissures of the bony and soft palate are found to coexist. In such cases, when the harelip is double as well as complicated, the *columna nasi* is generally deficient, and the portion of the lip intermediate between the two fissures is attached above to the tip of the nose and behind to the projecting intermaxillary bone, and seems to be an appendage of the nose rather than of the lip.

In the majority of cases, harelip occurs sporadically, not showing any remarkable tendency to affect different members of the same family. But I have become acquainted with two families in which nearly all of the children presented some variety of this malformation. In one of these families, the mother also had harelip.

¹ Contributions to Reporative Surgery, pp. 159-164.

Demarquay reports the case of a family in which, in three generations, eleven persons had either harelip or malformation of the lower lip.¹

The *treatment* of harelip consists in paring the margins of the fissure, bringing the two raw surfaces into close contact with each other, and holding them together by sutures until the two sides of the lip have become firmly united. This is a comparatively easy matter when the fissure is both single and simple, when the two sides of the lip are nearly symmetrical, when they are nearly parallel, and when they are not widely separated from each other. But under less favorable conditions, it is often a matter of great difficulty to secure union of the two sides of the lip without some remaining deformity. Without great care on the part of the surgeon, there is apt to be a want of conformity in the line of the vermilion border on the two sides of the lip, and there is often a more or less conspicuous notch in its free border.

It is very important, in order to insure the complete success of the operation, that the two sides of the lip should be brought together without tension, and that they should be maintained in close contact while, at the same time, the sutures are so applied as not to make injurious pressure.

In the simplest and most favorable cases, the following are the steps of the operation. A broad bandage is applied around the child's trunk and upper extremities, so as to prevent him from moving his hands during the operation. He is then placed upon a table or on the lap of an assistant, brought under the full influence of an anæsthetic, and kept in a supine position. A needle armed with a strong thread is next passed through the lip near the junction of one side of the fissure with the vermilion border, and the two ends of the thread are tied so as to form a loop about six inches in length. Another thread in like manner is passed on the other side of the fissure, and its ends secured in the same way. These loops facilitate the subsequent steps of the operation, by enabling the surgeon or his assistant to make traction in any required direction. The two sides of the lip are then drawn together, and if any resistance is offered to their close approximation, a free division of the mucous membrane and of the submucous cellular tissue is made on either side with scissors curved on the flat, until the resistance is completely overcome. The sides of the fissure are now to be pared so as to present broad surfaces denuded of integument. This is best accomplished by making downward traction by means of the loop of thread on one side of the fissure, and then inserting a Beer's cataract knife through the lip just above the loop, with its cutting edge looking upward, and cutting up towards the nose. The knife is then inserted on the other side of the fissure, and the incision completed in the same manner. It is not usually necessary to tie any vessels, as the lip can be compressed between the thumb and finger of an assistant until the surgeon is ready to apply the sutures. The edges of the wound are to be brought together by a pin passed through the two divisions of the lip, midway between its free border and the nose. The pin should enter on one side and emerge on the other about seven or eight mm. from the margin of the fissure, and should penetrate the whole thickness of the lip, except the mucous membrane. A number of turns of darning cotton should then be passed around the ends of the pin in the form of the figure 8. The sides of the lip should be brought together so that the two lateral portions of the vermilion border should exactly correspond. A second pin should be applied in the same manner at the junction of the skin with the vermilion border on each side. A third suture, of fine silk, should be applied near the junction of the lip with the nose. A fourth suture, also of fine silk, may be applied through the vermilion border, and a fifth through the mucous membrane. The two last

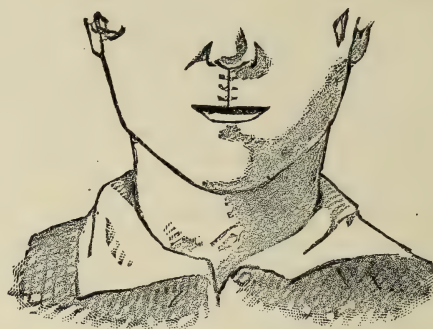
named sutures are often omitted, but I think that they secure a more perfect coaptation of the two divisions of the lip. I think it best to trust entirely to the sutures to hold the sides of the lip together, and to dispense with adhesive plasters, which are entirely unnecessary, and which are a source of discomfort and irritation. The sutures may be removed on the fourth or fifth day, and then the lip should be supported by a strip of adhesive plaster having a narrow isthmus across the lip, and a broad circular expansion over each cheek. If the support of the adhesive plaster be omitted after the removal of the sutures, there is reason to fear that the uniting medium may become attenuated, and that the middle portion of the lip may present an abnormal, sunken appearance. The adhesive plaster should be renewed from time to time, and its use should be continued for two or three weeks.

In cases in which the fissure is broad, and its margins widely divergent towards the free border of the lip, the edges may be pared by a semi-elliptical incision on either side, the concavities looking towards each other, and in this way the formation of a notch at the vermillion border may be avoided. (Figs. 997 and 998.)

Fig. 997.



Fig. 998.



Operation for harelip with divergent margins.

Or in cases in which the divergence is still greater, the method of Malgaigne, called by Agnew the method of Collis, may be adopted. This consists in leaving the flaps pared from the margins of the fissure, attached to the vermillion border of the lip, reflecting them downwards so that their raw surfaces are brought into contact. These flaps are trimmed to a proper length, and are then secured by sutures, so as to form a prominence beneath the inferior edge of the lip. (Figs. 999 and 1000.) I have found this a most effectual mode of guarding against the occurrence of a notch. After the wound has healed, and when the subsequent contraction has reached its full limit, if the prominence should continue, it may readily be reduced to its proper level.

In cases in which there is a marked inequality in the breadth of the two sides of the lip, the margin of the fissure on the narrower side may be pared three-fourths of the distance from the nose to the vermillion border, the incision being then sloped outwards to the free margin of the lip, while on the broader side the incision does not extend quite to the vermillion border, and

Fig. 999.

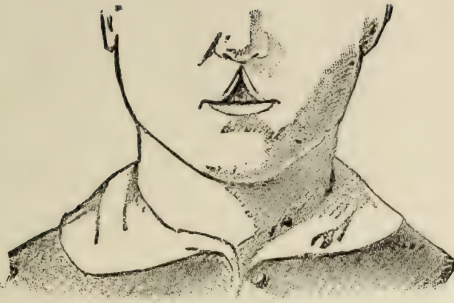


Fig. 1000.



Malgaigne's operation for harelip.

the small flap dissected from the margin is made to overlap the lower margin of the narrower side. (Figs. 1001 and 1002.)

Fig. 1001.

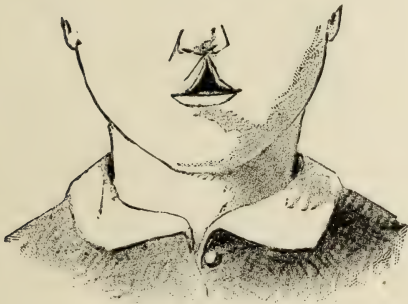
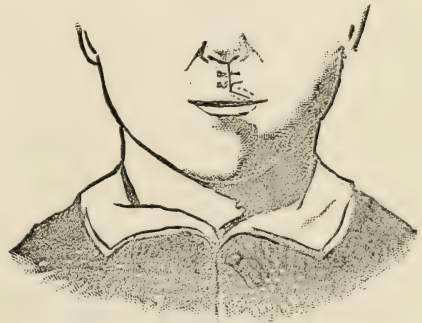


Fig. 1002.



Operation for harelip with marked inequality of sides.

When the fissure is very wide, and when the lateral portions of the lip cannot otherwise be approximated without undue tension, incisions may be made outwards into the cheeks from the junction of the lip with the nose, and, if necessary, from the angles of the mouth.

In cases of double harelip, not complicated with deformity of the jaw, if the portion of the lip intermediate between the two fissures is of considerable breadth, and extends nearly or quite down to the level of the free borders of the lateral portions, the operation may first be performed on one side, and after the wound has healed, and when the union has become firmly consolidated, may be repeated on the other. But when the intermediate portion is of smaller dimensions, the operation on both sides may be completed at the same time.

In cases of harelip complicated with intermaxillary projection, the prominent portion of the jaw may, in very early infancy, be pressed back to its proper level. This may be accomplished with the thumb and fingers, or with strong forceps guarded with buckskin. But when the bone has become too firm to be reduced in this way, it may be partly divided with Butcher's forceps, and then pressed back into its position. In children of larger growth, or in persons of mature age, the projecting portion of the jaw must be removed, with the aid of a saw, chisel, or cutting-forceps.

In cases of double, complicated harelip, where the columna nasi is deficient, and where the intermediate portion of the lip appears to be an appurtenance of the nose, this portion of the lip should be used in the reconstruction of the columna nasi. For this purpose it should be dissected off from the projecting portion of the bone, and should be reflected backward so that its posterior surface may be applied to the inferior part of the septum nasi, the two corresponding surfaces being freshened for the purpose, and being held in contact by one or more sutures. It is best, in such cases, to leave the new columna of its full breadth, until it has firmly united with the adjacent parts, and then to trim it to its proper size and shape.

There is a difference of opinion among surgeons as to the best time of operating for harelip, when the surgeon is consulted at the time of birth. There is a general agreement that the operation should be performed before the commencement of dentition. In cases of simple harelip, whether the fissure be single or double, I would recommend the performance of the operation about three or four months after the birth of the child, as at that time the parts have acquired a good degree of development, and the irritation of dentition has not yet commenced. But in cases of complicated harelip, whether there be maxillary projection, or fissure of the alveolar portion of the jaw and of the bony palate, it is better to operate at a much earlier period, as the pressure of the reconstructed lip exerts an important influence in diminishing the deformity of the bones while they are in a soft and yielding condition. Some surgeons recommend the performance of the operation on the day of the child's birth. This practice seems to me objectionable, as the child has not yet recovered from the shock attending the transition from intra-uterine to extra-uterine life. New-born infants generally lose weight during the first week of extra-uterine life, and do not regain what they have lost until after the lapse of another week. I think that the most favorable time for the performance of the operation, in these complicated cases, is when the child is three or four weeks old, as at that time the functions of extra-uterine life, circulation, respiration, and digestion, have become fully established, and the bones of the face have not yet undergone any remarkable increase of solidification.

If the surgeon is not consulted until the child is five or six months old, it is generally best to defer the operation until the first dentition is completed, as during the progress of dentition children are more subject than at other periods to convulsions and other serious derangements of the nervous system.

A congenital fissure in the median line of the lower lip has been observed in a very small number of cases. The treatment is like that of simple harelip.

WOUNDS OF THE LIPS.

These wounds bleed very freely, but the hemorrhage may be readily arrested by torsion or by ligature; or the sutures, by which the wound is closed, may be so adjusted as to compress the bleeding vessels. When the





Epithelioma of face.

(From a Patient in the Hospital of the University of Pennsylvania.)

wound involves the vermilion border, the edges should be very carefully adjusted by sutures, so as to guard against the occurrence of permanent fissure, and secure perfect symmetry in the line of union.

FURUNCLE AND CARBUNCLE OF THE LIPS.

These forms of gangrenous inflammation are often observed in the lips. They are very painful, and are often attended with marked symptoms of cerebral disturbance, sometimes leading to fatal results. The special danger of the disease in this situation has been ascribed to absorption of septic poison by the facial vein. The most reliable treatment consists in free incision through the whole thickness of the inflamed and indurated parts, followed by stimulating dressings, such as lint moistened with oil of turpentine, or balsam of Peru. The best results are obtained when the incision is made at a very early period of the disease. The incision should be made through the free border of the lip.

At a very early stage of the disease, the morbid action may be promptly arrested by the application of a cauterizing needle to the depth of three or four millimetres, at several points along the labial margin. If this is done under the influence of an anæsthetic, it is not a severe remedy, and it does not disfigure the patient.

FISSURES OF THE LABIAL MARGIN, OR CRACKED LIPS.

These are usually the result of exposure to cold, and they are most apt to occur when there is some derangement of the general health. When the lip is stretched, they are very painful, and they are disposed to bleed. They will generally heal when they are protected from cold and are occasionally touched with sulphate of zinc, sulphate of copper, or nitrate of silver. When they are neglected, they may lead to deep ulceration of an intractable character, sometimes requiring excision. Obstinate fissures at the angles of the mouth should lead to careful investigation as to a possible syphilitic origin.

ULCERS OF THE CHEEKS AND LIPS.

APHTHOUS ULCERS of the mucous membrane of the lips are apt to be very painful. Great relief is often afforded by touching them with sulphate of zinc, sulphate of copper, or nitrate of silver, but the application for the moment gives severe pain. Attention should always be paid to the general health, and especially to the digestive organs. A charcoal mixture, or a mixture of rhubarb and soda, will often be of great service.

LUPUS.—This disease may affect the lips and cheeks, assuming the form of either lupus exedens or lupus non-exedens. It often greatly disfigures the patient. The affected parts may be excised, or they may be destroyed by the actual or potential cautery. If the extent of the disease be limited within narrow bounds, the edges of the wound, after incision, may be brought into contact, and secured by sutures. But when there has been great loss of substance, a plastic operation will be required to fill up the chasm.

RODENT ULCER and EPITHELIOMA (Plate XXXI.) may both occur in the same situations as lupus, and may require substantially the same treatment.

SYPHILITIC AND CHANCROIDAL ULCERS may occur upon the lips, the virus of the former being usually applied in the act of kissing. These sores present in their main features the same characters, and require the same treatment, as when they are found on the genitals.

CANCER OF THE LIP.

This is a very common disease in the male subject after the age of forty-five years. It affects almost exclusively the lower lip, although, in some rare instances, it has been observed in the upper lip. It is comparatively rare in females. In the great majority of cases it presents the characters of epithelioma. There seems to be good reason to believe that tobacco smoking plays an important part in the production of the disease, and that it occurs more frequently in those who smoke clay pipes, than in those who use other kinds of pipes, or who smoke cigars. Dr. J. Mason Warren, in his *Surgical Observations*, gives the statistics of all the cases of cancer of the lip which had occurred at the Massachusetts General Hospital for forty years:—

Whole number of cases	77
Males	73
Females	4
No. of those that smoked pipes	44
No. that did not smoke pipes	7
Not ascertained	26

Of the four women, three were known to have smoked pipes. Epithelioma of the lip, in its earliest stage, may present itself as a simple desquamation of the cuticle at the margin of the lip, with a slight induration of the subjacent tissue, or there may be a crack or fissure, or a wart-like growth from the surface, or a small, hard tubercle like a shot imbedded in the part. In either case, there is apt to be some induration, but it is often very slight. The disease, in its early stage, is often quite indolent, scarcely giving rise to any symptoms, and frequently remaining many months without making any considerable progress. After a time, varying greatly in different cases, it assumes a more active character, extending along the vermilion border and through the substance of the lip, and giving rise to lancinating pains. At a later period, ulceration takes place, with an offensive sanious discharge, and the disease extends along the lymphatics to the glands beneath the base of the jaw, and involves all the adjacent tissues, including the periosteum and the bone. The general health becomes seriously disturbed, and the continued irritation and exhaustion, occasioned by the disease, ultimately destroy the patient's life.

Treatment.—The only safety of the patient lies in the early and complete extirpation of the parts involved in the disease. This may be accomplished by the thorough application of powerful escharotics; but their action is painful, slow, and uncertain in its results. Excision with cutting instruments is more prompt, more safe, and more certain, and is attended with much less pain and discomfort to the patient. It is also followed by a much smaller deviation from the normal appearance of the face, and is, therefore, on all accounts to be preferred. When the disease involves less than half of the vermilion border of the lip, it may readily be included in the limits of a V-incision, and the margins of the wound may be brought together with pin sutures in such a manner as scarcely to mar the appearance of the patient. When a larger portion of the lip is involved in the disease, it may be excised

by a semi-circular, a semi-elliptical, or a quadrangular incision, and the chasm thus produced may be closed by an appropriate cheiloplastic operation.

When epithelioma of the lip is removed at a very early period, there is good reason to hope for a radical cure, or, at least, for a long reprieve. But if the operation be delayed until the lymphatic system has become involved, and till the general health has begun to suffer from cancerous cachexia, little or no benefit is to be expected from the excision of the morbid growth.

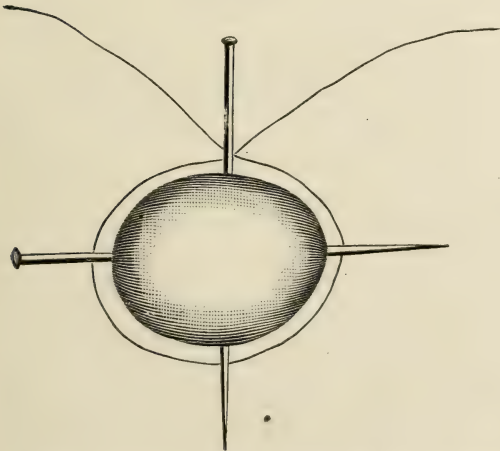
TELANGEIECTASIS OF THE LIPS.

This is usually a congenital affection. It may affect the vessels of the skin or mucous membrane alone, or those of the subjacent cellular tissue, or both tissues may be involved. When the disease is of very limited extent it may be excised, and the edges of the wound may be united by sutures.

When it is more extensive, it may be treated by inserting cauterizing needles, at a dull-red heat, into the tumor at a number of points.

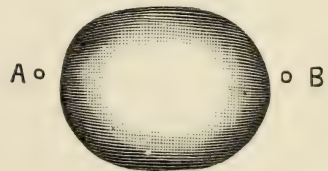
When the morbid growth is quite prominent, without a very wide base, it may be treated with two pins traversing its base and crossing at right angles, and a strong ligature tied around the base of the tumor under the pins, with sufficient force to arrest the circulation and to destroy the vitality of the included parts. After the separation of the slough the sore will heal, and the cicatrix will not much disfigure the patient. Fig. 1003 shows the pins *in situ*, traversing the base of the tumor, and the ligature ready to be tied. It will sometimes be advantageous to apply the ligature around the base of the tumor subcutaneously, as represented in Fig. 1004. A curved

Fig. 1003.



Telangeiectasis of lip strangulated with pins and ligature.

Fig. 104.



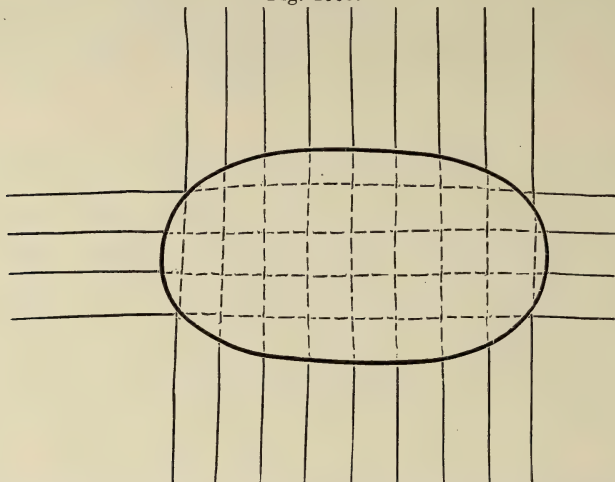
Application of subcutaneous ligature.

needle armed with a strong ligature is passed through the integument at the point A, on one side of the tumor, and is carried beneath the skin around half the circumference of the tumor to the point B, on the opposite side. It is then re-inserted at the point B, and carried from B to A around the other half of the circumference, and thus the two ends of the thread at A may be tied so as to strangulate the tumor subcutaneously.

When the tumor is flat and has a broad base, it may be treated by passing needles armed with double ligatures through its base, at a number of points,

and tying in sections until the whole circumference is strangulated. Or a number of parallel ligatures may be passed through the tumor, and intersected

Fig. 1005.



Telangelectasis of lip strangulated by ligatures crossing each other at right angles.

by others at right angles, as represented in the diagram. (Fig. 1005.) When the two ends of each ligature are firmly tied in the direction of the dotted lines, the whole mass will be divided into quadrangular segments, and the vascular growth will be obliterated.

PORT-WINE MARKS.

Dark discolorations of the integument of the face, forming circumscribed patches resembling in color the stains occasioned by port wine, are sometimes observed as a congenital affection. They are only important as affecting the personal appearance of the patient. When they are small, they may be excised, or the surface may be destroyed by means of the actual or potential cauter. In 1876, a pamphlet was published by Dr. Balmanno Squire, describing his method of treating port-wine marks. His plan is to freeze the part by the ether-spray apparatus, then scratch it with an ordinary cataract needle in parallel lines about one-sixteenth of an inch apart, then place a piece of blotting paper on it before it has thawed, pressing the paper firmly on the scratched skin for five minutes. Next day he repeats the operation if necessary, the lines being in an oblique or transverse direction to the original scratches. The scratches need not divide the entire thickness of the skin. The part must be well frozen, both that the operation may be painless, and to avoid any hemorrhage. In applying the blotting-paper, the pressure should be absolutely perpendicular to the surface; for if the slightest lateral traction be made, the miniature incisions will gape slightly, and so become plugged with minute, wedge-shaped clots of blood, with resulting, indelible, linear scars. After relaxing the pressure, the paper should be allowed to remain for at least half an hour. Then it should be thoroughly wetted, and gently removed, traction being made in the same direction as the incisions, so as not to tear them open. The thin clot of blood which covers the part after removal of the paper, should be gently washed off with a camel's hair brush and cold water, and then a film of glycerine should be carefully applied.

Dr. Squire has since proposed to make the linear incisions of the skin oblique instead of perpendicular to the surface, and has devised an instrument for the purpose, which he calls a multiple linear scarifier.¹

CYSTS OF THE LIPS.

Cysts, arising from distension of the follicles and containing a viscid fluid, are sometimes found at the margins of the lips. They may be excised, or they may be laid open so as to evacuate the fluid, and the surface may then be wiped with lint and cauterized with nitric or sulphuric acid.

TUMORS OF THE LIPS.

Tumors of various kinds occasionally present themselves in the lips, such as steatomata, adenomata, papillomata, myxomata, sarcomata, fibromata, and lipomata. Soft papillomata may be destroyed by escharotics, but the other varieties of tumor may more advantageously be excised.

HIRSUTIES.

A growth of hair from the lips and cheeks, in the female, is often an occasion of great annoyance. When they are not very numerous, the hairs may be plucked individually with forceps, and the evulsion may be repeated as often as they are reproduced. Dr. Agnew recommends, as a depilatory, three parts of prepared chalk and one part of sulphide of calcium, mixed into a paste with water, and applied to the surface with a brush. After it has dried, it may be rubbed off, and the hairs are removed with it; but, after a while, they are reproduced. A radical cure may be effected by destroying the hair follicles, one by one, by inserting into them a platinum needle and connecting it with the poles of a galvanic battery.

CHEILOPLASTIC OPERATIONS.

These operations consist in the transplantation of flaps to supply new material for the reconstruction of the lips, when a considerable portion of their substance has been destroyed by disease or by injury. The flaps employed for this purpose are, for the most part, taken from adjacent parts of the face or neck, and are left attached by pedicles to the parts from which they derive their nourishment until they have become firmly adherent in their new position, and have obtained a new vascular supply from the parts into which they have been inserted. The grafting of flaps without a pedicle is not well adapted to the supply of new tissue in a part as movable as the lip, and which cannot well be kept entirely at rest and subjected to pressure, on account of the necessity of introducing food into the mouth. To remove the deformity arising from a loss of substance of the lips, in such a manner as to restore the symmetry of the mouth, often taxes the ingenuity of the surgeon to its utmost limits. The operations which have been devised for this purpose present a great variety of details, according to the nature

¹ See Med. Record, Feb. 17, 1877, p. 107, and Jan. 17, 1880, p. 64; Med. Press and Circular, Nov. 26, 1879; Quarterly Epitome of Pract. Med. and Surg., March, 1880, p. 91.

and extent of the deformity, and the character of the material of which the surgeon can avail himself in restoring the disfigured features to a condition approaching as nearly as possible to their normal configuration. To obtain anything like a satisfactory result, it is essential that the transplanted flaps should be composed externally of skin, and internally of mucous membrane. The lips and cheeks are the only available material for this purpose, and the French method of approximating the transplanted flaps to the part to which it is to be attached, without twisting its pedicle, is the only method of which we can ordinarily avail ourselves. The disadvantage of this method, in cases where there is a large chasm to be filled up, is that the flaps cannot be adjusted to each other without such a degree of tension as to endanger the success of the operation. This difficulty may sometimes be overcome by making free incisions beyond the base of the flap, to relieve the tension, and by allowing the space thus made vacant to heal by granulation and cicatrization. The healing of this space may sometimes be promoted by skin-grafting.

Another mode of relieving the tension of the flaps is to give a very considerable curvature to their peduncles. In many cases the success of the operation will greatly depend on the adoption of this expedient. In cases in which there is a very great relative deficiency of the lower lip and superfluity of the upper lip, or *vice versa*, a flap may be transplanted from the superfluous lip to supply material to the defective one, by one of the ingenious processes of the late Dr. Gurdon Buck. This seems to be almost the only condition in which a cheiloplastic operation may be advantageously performed by the Indian method. In cases in which there is a very contracted state of the mouth, and in which there is no available mucous membrane in the vicinity to invest the borders of the lips which are to be reconstructed, it has occurred to me that the difficulty might be obviated by transplanting a flap of integument from the neck, and inserting it through an incision along the base of the lower jaw, so as to line the outer integument, and supply the place of mucous membrane. When there is no suitable integument in the immediate vicinity of the face, a flap of integument may be partially detached from the thorax or abdomen, and attached to the margin of the hand or forearm, and at a later period it may be secondarily transplanted so as to form a mucous lining in the lip or cheek.

Cheiloplastic operations may be divided into four classes, according as they are designed (1) to supply deficiencies of the upper lip; (2) To supply deficiencies of the lower lip; (3) To supply deficiencies of both lips; and (4) To supply deficiencies or correct malpositions of the angles of the mouth.

In cases of harelip, in which there is a very wide chasm to be filled, it is sometimes necessary to make an incision outward and backward on each side from the angles of the mouth, through the whole thickness of the cheeks, and a parallel incision at the junction of the lip with the nose, thus making flaps from each side to bridge the chasm. In such cases, a new vermilion border to the upper lip is made by attaching the mucous membrane to the skin by fine sutures. If the flaps do not meet without tension, the incisions may be prolonged in a curved direction outward and downward, until the tension is entirely relieved.

Dieffenbach proposed a plastic operation for the restoration of the upper lip, by making a vertical incision upward from the angle of the mouth to a point above the level of the nostril, thence making a horizontal incision outward to an extent fully equal to the breadth of the space to be occupied by the reconstructed lip, and thence a vertical incision downward nearly to the level of the angle of the mouth, thus making a quadrangular flap remaining attached below. This flap was to be turned horizontally inward, so that its

upper border should in the median line be secured by sutures to a corresponding flap on the opposite side. (Figs. 1006 and 1007.)

Fig. 1006.

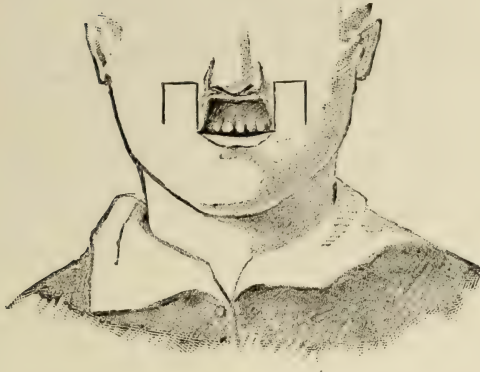
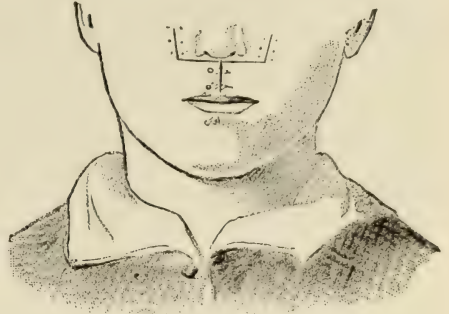


Fig. 1007.



Dieffenbach's operation for restoration of upper lip.

Sédillot proposed another operation by which the restoration of the upper lip was to be effected by means of flaps cut in the reverse direction from that proposed by Dieffenbach. The flap on each side was bounded by a vertical line, commencing at a point midway between the angle of the mouth and the lower eyelid and ending midway between the angle of the mouth and the base of the lower jaw; a horizontal line extending outward from the lower extremity of the vertical line, and another vertical line extending upward from the outer end of the horizontal line to a point on a level with the nostril. These flaps were then to be turned so that their lower extremities should meet and be joined by sutures in the median line. (Figs. 1008 and 1009.)

Fig. 1008.

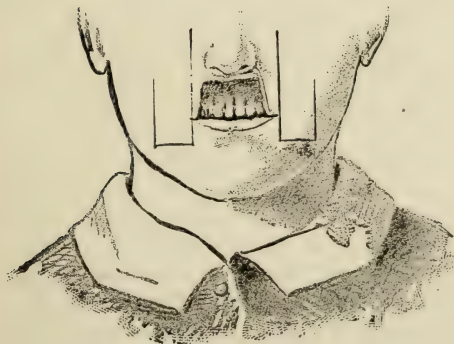
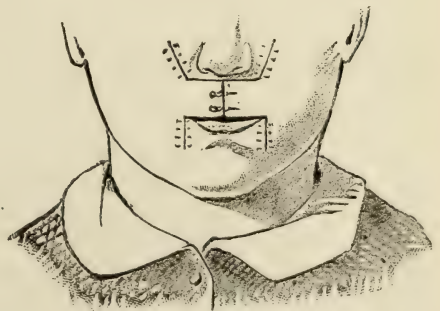


Fig. 1009.



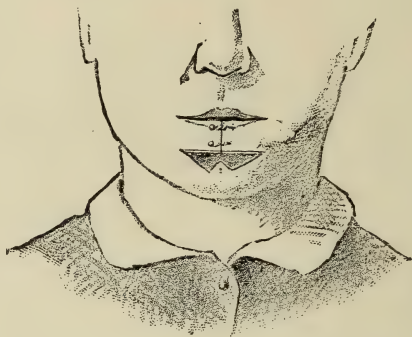
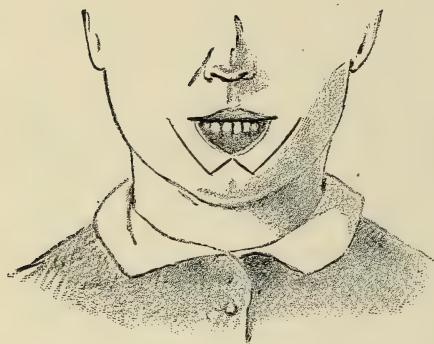
Sédillot's operation for restoration of upper lip.

Deficiencies in the lower lip are apt to exist to a greater extent than those which occur in the upper lip. Malignant disease is the most frequent cause

of these extensive deficiencies. When a cancer of the lower lip occupies so large a portion of its margin that it cannot be excised by a V-incision, allowing the opposite sides to be brought into contact and secured by sutures, a plastic operation is required for the reconstruction of the lip. When the disease involves nearly the whole of the vermilion border, but does not extend very far towards the chin, the operation proposed by Buchanan may be performed with advantage. In this operation, the morbid growth is removed by a semicircular incision, and then a flap is cut on each side, bounded above by the incision referred to, below by a parallel curved incision, and within by an oblique incision extending on each side of the median line downward and outward from the upper to the lower curved incision. These flaps are drawn upward and inward so as to meet in the median line, and their upper margins are brought into contact with the upper lip, leaving a considerable chasm to granulate between their lower borders and the chin. (Figs. 1010 and 1011.) This chasm may sometimes be filled up by making an incision

Fig. 1010.

Fig. 1011.



Buchanan's operation for restoration of lower lip.

through the integument of the neck, nearly parallel on the sides with the lower border of the chasm, but the two lateral portions as they approach the median line extending downwards and meeting at an acute angle in the median line. The flap thus made may be drawn upward to meet the upper margin of the chasm, and the sides of the triangular space below may be united by sutures.

Instead of Buchanan's operation, the tumor may be removed by including it in a quadrangular incision, bounded above by the free border of the lip, below by a horizontal line parallel with the free border, and on each side by a vertical line extending from the labial margin to the lower horizontal line. The two vertical lines are then extended downward below the base of the jaw, and the flaps thus formed are used to fill up the space which had been occupied by the excised portion of the lip. The objection to this mode of operating is that it is difficult to prevent the new margin of the lip from sinking down below its proper level. I think that this difficulty might be obviated by dividing the base of the flap into two lateral segments separated from each other by a triangular portion of integument, and then curving these lateral peduncles outward and upward so as to relieve the tension of the flap. The triangular chasm between the two peduncles could then be closed laterally by

sutures. Whichever of these methods may be adopted for supplying deficiencies of the lower lip, a new vermilion border should be made, when it is practicable, by uniting the mucous membrane with the skin by means of fine sutures. When this cannot be accomplished, the free border of the lip may be invested with skin, if this material can be obtained for the purpose.

The operations of Dr. Buck for the transplantation of a portion of the upper lip to supply a deficiency of the lower lip, or of a portion of the lower lip to supply a deficiency of the upper lip, are described in his *Contributions to Reparative Surgery*, published in 1876.¹

He first describes two preliminary operations for the removal of extensive disease of the lower lip.

The first of these preliminary operations is performed by including the diseased mass between two incisions extending downward and inward from a point on each side near the angle of the mouth, and meeting in the median line of the neck beneath the chin. The mucous membrane is then freely divided on each side at its reflection from the cheek to the jaw, and the margins of the wound are drawn together, and united by pin sutures.

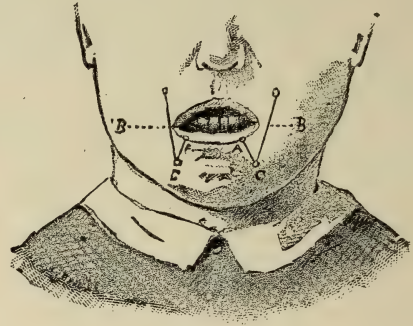
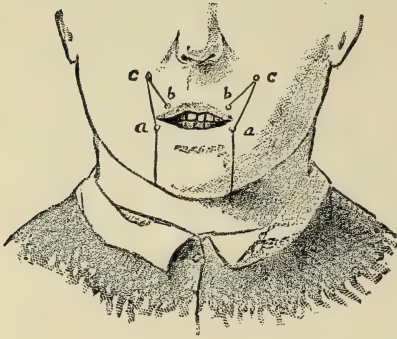
The second preliminary operation, which is adapted to cases in which the extent of the disease is so great as to forbid the first operation, consists in the exsection of the tumor by two vertical incisions extending downwards from the commissures of the lips, and a horizontal incision extending from one of the vertical incisions to the other, below the diseased mass. The horizontal incision is then extended to the right and left, to within a finger's breadth of the angle of the jaw, and thence curved upward and a little forward over the masseter muscle to the extent of about two inches. The flaps are then dissected from the subjacent parts, and their edges brought together in the median line, and secured by pin sutures. The vacant spaces behind the posterior vertical incisions may be allowed to heal by granulation, or the integument may be dissected up from the parts behind, and united by sutures with the posterior margins of the flaps. After the healing of the wounds made by either of these preliminary operations, the mouth is much disfigured, the angles being much approximated and the upper lip being redundant, and overhanging the lower lip which is extremely contracted. The secondary operation, which is designed to transfer the redundant portions of the upper lip, so as to relieve the contracted state of the lower lip, and thus to restore the symmetry of the mouth, is performed as follows: A point is selected about a finger's breadth below and a little without the angle of the mouth on each side, and this point is marked by inserting a small pin through the skin. Another pin is inserted on each side at the junction of the vermilion border of the upper lip with the skin, about one-fifth of the distance from the angle of the mouth to the median line of the lip; and a third pin on each side is inserted into the integument of the cheek, about an inch and a half above and without the angle of the mouth. The points indicated by the first and third pins are then to be united by an incision through the entire thickness of the cheek, and, in like manner, the points indicated by the second and third pins. A triangular flap is thus formed, with its base towards the angle of the mouth, and from the point indicated by the first pin a vertical incision is made down to the base of the jaw. The integument in this region being in a state of great tension, the edges recede and form a space for the reception of the triangular flap with its apex towards the base of the jaw, and its base, including a portion of the vermilion border of the upper lip, supplying the deficiency of the corresponding side of the lower lip. When this operation is completed on both sides, it greatly improves the configuration of the mouth.

¹ *Contributions to Reparative Surgery*, chap. v. pp. 20-30. New York, 1876.

With slight modifications, this operation may be reversed, the redundancy of the lower lip contributing to supply the deficiency of the upper. (Figs. 1012 and 1013.)

Fig. 1012.

Fig. 1013.



Buck's operation for restoration of lower lip.

Dr. Buck's second operation, which is designed, in certain cases of deficiency of one side of the upper lip, to supply material from the lower lip, is performed in the following manner: The upper lip on the defective side is separated from the cheek by a vertical or slightly oblique incision, involving its whole thickness, and extending downward an inch below the angle of the mouth. From the lower part of this incision, a second incision is made, extending inward almost to the median line, and a third incision, from the inner extremity of the second, upward half way to the vermilion border. The opposite half of the upper lip is to be prepared for the reception of the flap from the lower lip by free incision of the mucous membrane connecting it with the jaw, and by paring its edge, so as to leave a raw surface. The flap from the lower lip is then turned edgewise so as to meet the opposite side of the upper lip, the vermilion border of the lower lip being reversed so as to form a part of the border of the upper lip. The flap is attached by sutures in its new position. When the healing process has been completed, the commissure of the lips presents a circular instead of an angular form, and requires another operation to give it its proper shape. This operation is performed in the following manner: A curved incision is made along the line of junction of the skin with the vermilion border, extending to an equal distance along the upper and lower lips. This incision should divide the skin and the subcutaneous tissue, but should not involve the mucous membrane. A sharp-pointed double-edged knife is then inserted between the skin and mucous membrane, and these parts are freely separated from each other, as far outward as the point where the new angle of the mouth is to be constructed. The skin alone is then divided with strong scissors along the line which is to separate the upper from the lower lip. The mucous membrane is next divided along the same line, but not as far outward, the difference in the length of the two incisions being a little less than the thickness of the cheek. The mucous membrane at the outer extremity of the incision is then connected with the skin by a suture, so as to form the new angle of the mouth, and the borders of the upper and lower lip are recon-

structed by uniting with the sutures the skin and mucous membrane, after paring thin slices of skin from the upper and lower borders of the wound.

Fig. 1014.



Buck's operation for restoration of upper lip.

Cheiloplastic operations are subject to great variety of detail, according to the nature and extent of the deformity, and of the material in the neighborhood which may be utilized for transplantation.

Fig. 1015.

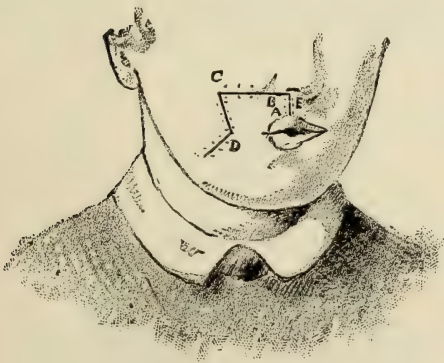
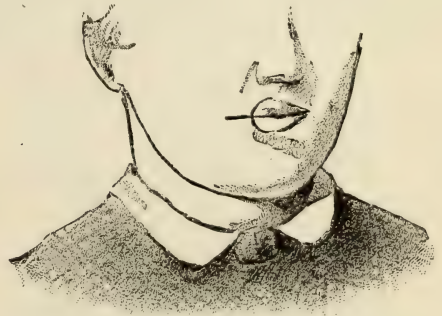


Fig. 1016.



Buck's operation for restoration of upper lip.

A number of these operations are illustrated in the Atlas accompanying a work published in 1842, by M. Serre.¹

I have selected a few of these illustrations, as containing valuable hints for the guidance of surgeons in restoring the lips as nearly as possible to a normal condition after a considerable loss of substance. Fig. 1017 represents the manner of removing a morbid growth involving nearly the whole of the

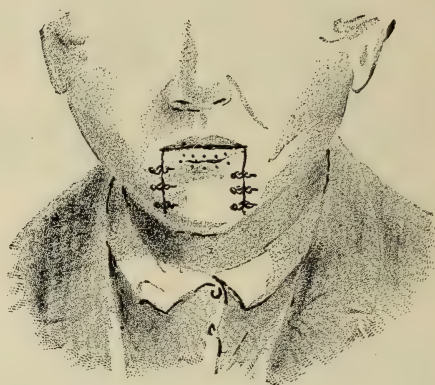
¹ *Traité sur l'art de restaurer les Difformités de la Face, etc.* Montpellier, 1842.

vermilion border of the lower lip, by two vertical incisions extending down from the angles of the mouth, and a horizontal incision below the inferior part of the neoplasm. The vertical incisions are extended downwards below the chin, and a quadrilateral flap is dissected from the subjacent parts and drawn up until it comes in contact with the upper lip. The mucous membrane at the upper extremity is united with the skin by fine sutures, so as to form a new vermilion border, and the flap is united on each side with the adjacent integument by pin-sutures, as represented in Fig. 1018.

Fig. 1017.



Fig. 1018.



Cheiloplasty of lower lip. (After Serre.)

Fig. 1019 represents a tumor involving three-quarters of the vermilion border of the lower lip, and extending upward and outward beyond the left angle of the mouth. The tumor is included between two vertical incisions

Fig. 1019.

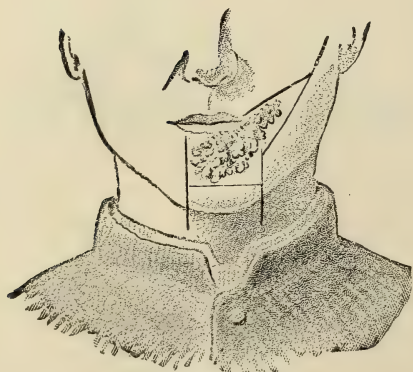
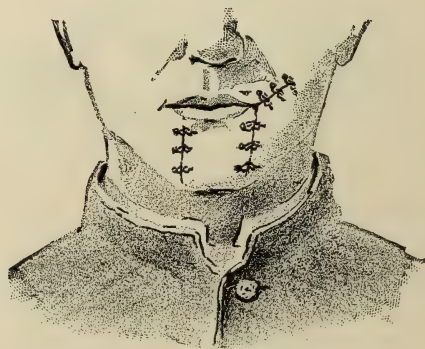


Fig. 1020.



Cheiloplasty of lower lip and angle of mouth. (After Serre.)

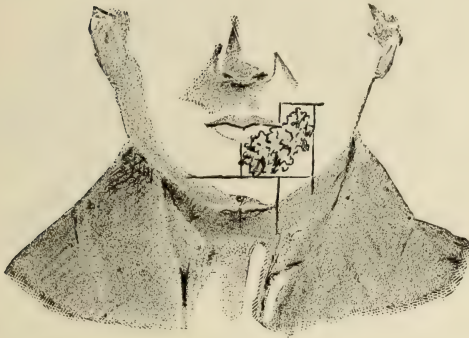
joined by a horizontal incision below, and two oblique incisions including the angle of the mouth and terminating at an acute angle on the left cheek.

Fig. 1020 represents the reconstructed mouth with the flaps secured by sutures in their new position.

Fig. 1021 represents a tumor in nearly the same situation, removed by vertical and horizontal incisions, which are extended so as to form a transverse flap on the right side, and a vertical flap below the left extremity of the tumor. Fig. 1022 represents these flaps drawn into such a position as to fill up the vacant space.

Fig. 1021.

Fig. 1022.

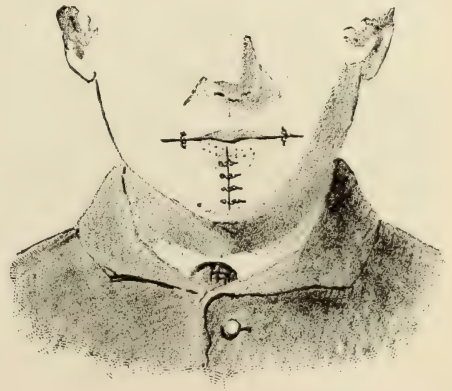
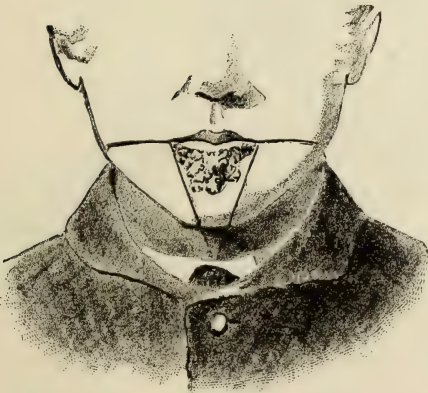


Cheiloplasty of lower lip and angle of mouth. (After Serre.)

Fig. 1023 represents a tumor occupying nearly the whole of the vermillion border of the lower lip, included between two incisions extending downward and inward from the angles of the mouth, and meeting at an acute angle on

Fig. 1023.

Fig. 1024.



Restoration of lower lip. (After Serre.)

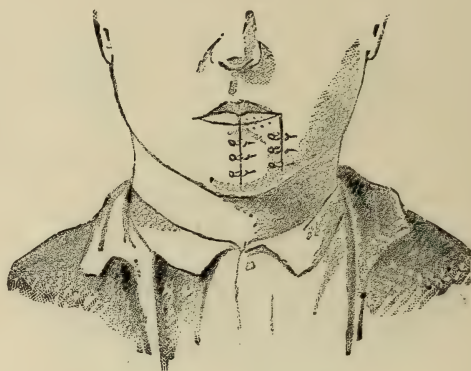
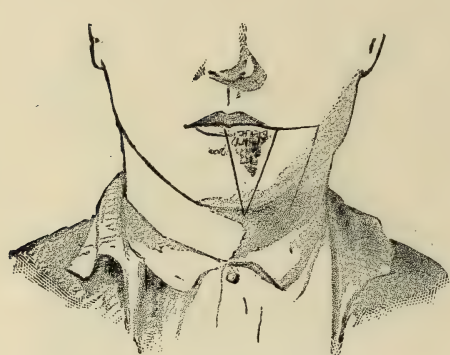
the anterior part of the neck below the chin. From the upper part of these lateral incisions, a nearly transverse incision on each side extends into the

corresponding cheek, and thus two lateral flaps are formed, which are drawn together so as to meet in the median line as shown in Fig. 1024.

Fig. 1025 exhibits a tumor involving the left half of the vermilion border of the lower lip, included between two incisions meeting at an acute angle below the base of the jaw. To cover the vacant space, a quadrangular flap is cut on its outer side, and drawn towards the median line, where it is fixed by sutures, as shown in Fig. 1026.

Fig. 1025.

Fig. 1026.

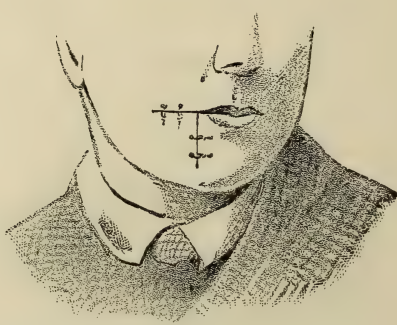
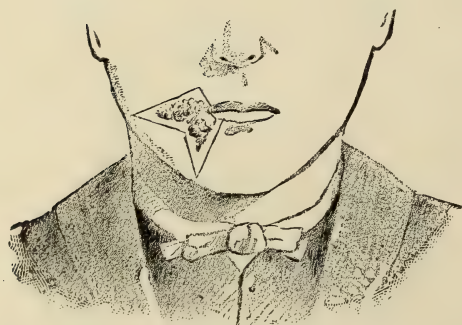


Restoration of left half of edge of lower lip. (After Serre.)

Fig. 1027 exhibits a morbid growth, extending from the right commissure of the lips downward and outward, and included between incisions meeting at two acute angles, so as to form two triangular spaces meeting at their

Fig. 1027.

Fig. 1028.



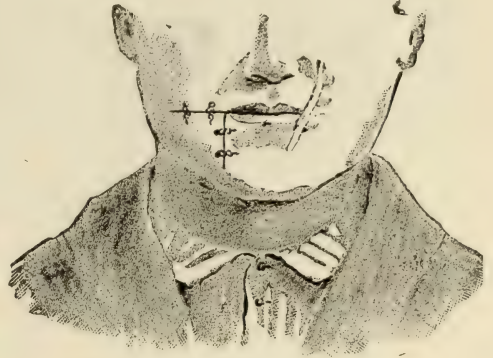
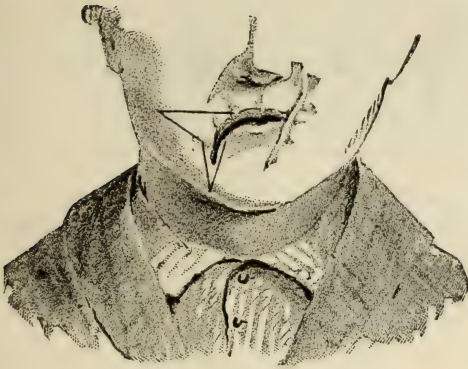
Operation for growth involving right commissure of lips. (After Serre.)

bases, and closed by drawing the adjacent integuments together so as to form a transverse and a vertical line of junction as exhibited in Fig. 1028.

Figs. 1029 and 1030 exhibit a similar proceeding for the removal of a distortion of the right angle of the mouth occasioned by cicatricial contraction.

Fig. 1029.

Fig. 1030.

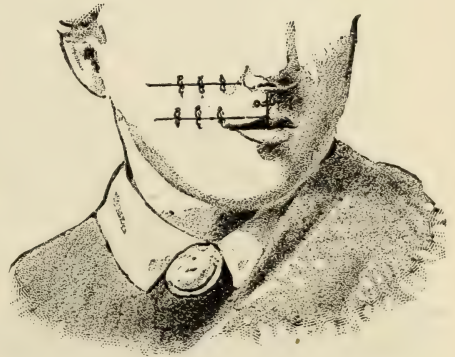
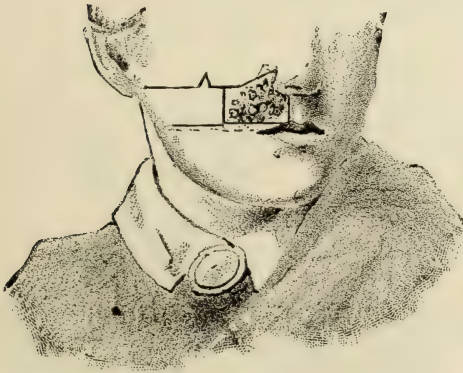


Operation for cicatricial contraction of right angle of mouth. (After Serre.)

Figs. 1031 and 1032 represent the wound left by removing a tumor of the right half of the upper lip, encroaching on the ala nasi, and the vacant space covered by a horizontal flap with a small triangular prominence adapted to the nasal deficiency.

Fig. 1031.

Fig. 1032.



Restoration of upper lip and ala nasi. (After Serre.)

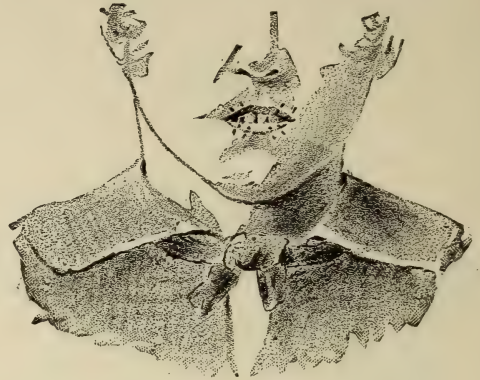
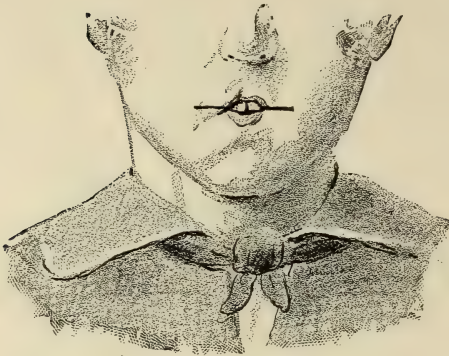
Fig. 1033 represents a mouth contracted to a small ring, enlarged by a transverse incision on each side into the cheek. Fig. 1034 represents the reconstruction of the buccal orifice by the attachment of the mucous membrane to the skin on each side, so as to complete the vermillion border of the lips.

A very ingenious method of restoring the symmetry of the lips after a

considerable loss of substance of the upper or lower lip, is described by Carl August Burow.¹

Fig. 1033.

Fig. 1034.

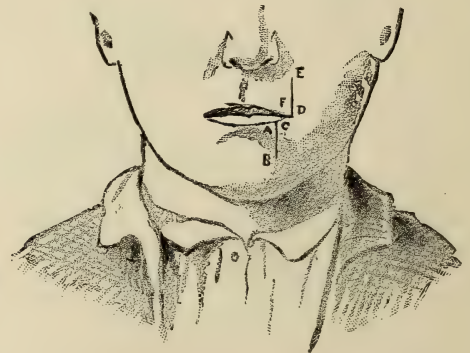
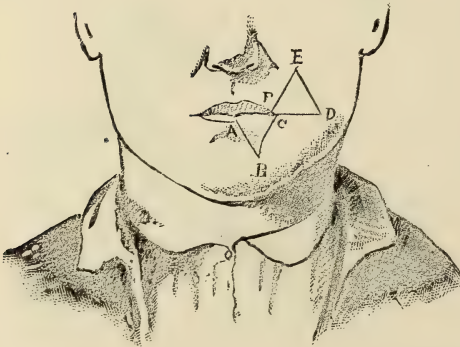


Reconstruction of buccal orifice. (After Serre.)

Fig. 1035 furnishes a representation of the application of this method to a case of deficiency of the left half of the lower lip. The diseased portion of the lip having been excised by the incisions AB and BC, leaving a triangular chasm ABC, a transverse incision, FD, is extended from the angle of the mouth into the cheek, and from the two ends of this incision the incisions FE and DE are made so as to excise the triangle FED.

Fig. 1035.

Fig. 1036.



Burow's plastic operation.

Fig. 1036 represents the reconstruction of the mouth by joining the line AB to AC, and the line EF to ED. This method of operating may be adapted to a considerable variety of deformities of the lips. The principal

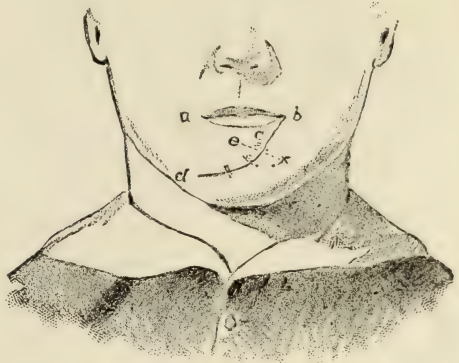
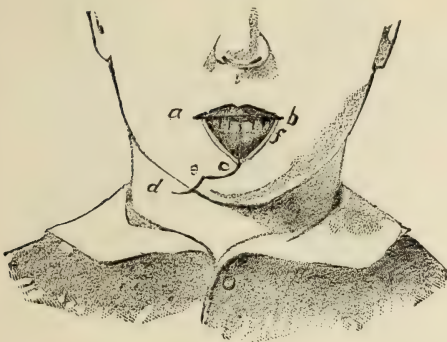
¹ Beschreibung einer neuen Transplantations-Methode (Methode der seitlichen Dreiecke) zum Wiedersatz verlorengener Theile des Gesichts. Berlin, 1855.

objection to it is that it involves the loss of a considerable portion of healthy integument. But there are cases in which the symmetry of the lips can be better secured by it than by any other method.

Szymanowski¹ gives illustrations and descriptions of a number of ingenious operations for the removal of deformities of the lips. I have selected a number of these illustrations, and I have no doubt that many useful hints may be derived from their careful study. Fig. 1037 exhibits a triangular chasm produced by the excision of a tumor involving the whole of the vermillion border of the lower lip, and a flap of integument on the right side which is designed to be drawn upward and to the left, so as to fill the chasm. Fig. 1038 represents the flap secured in its new position by sutures.

Fig. 1037.

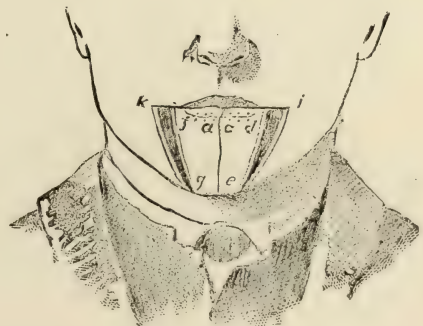
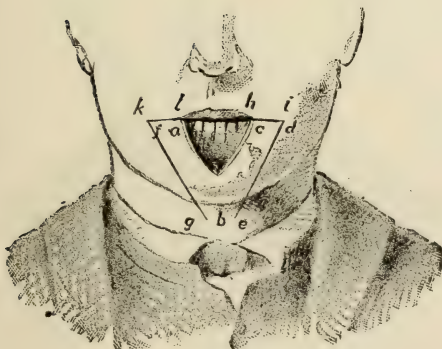
Fig. 1038.



Restoration of edge of lower lip. (After Szymanowski.)

Fig. 1039.

Fig. 1040.



Restoration of whole lower lip. (After Szymanowski.)

Fig. 1039 represents a somewhat more extensive triangular chasm, the apex of which extends to the chin, and a quadrilateral flap on each side, designed

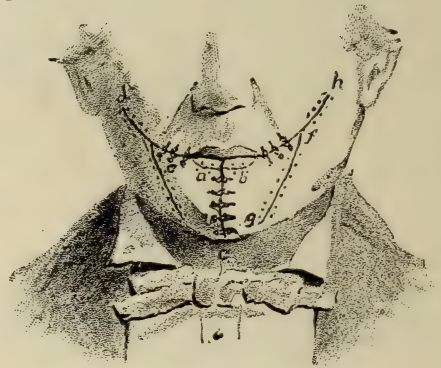
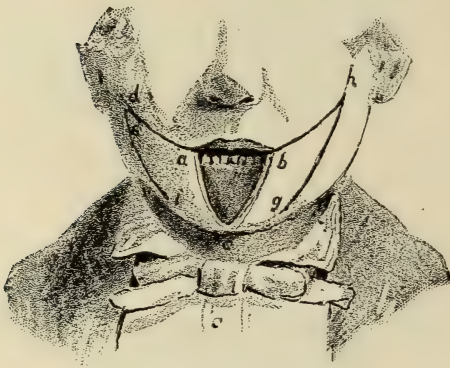
¹ Handbuch des operativen Chirurgie. Braunschweig, 1870.

to be joined together in the median line, as represented in Fig. 1040, leaving on each side a narrow chasm to be filled by granulation.

Fig. 1041 exhibits a different mode of forming flaps to close a triangular chasm extending from the free border of the lower lip to the chin. The flaps as seen in the diagram are curved, and terminate above at acute angles, so that when the flaps are brought together in the median line, the integument above their apices can be readily united by sutures without puckering. In many cases, flaps constructed in this way will close the chasm with less disfigurement than when any other method is employed. Fig. 1042 exhibits the appearance of the parts when the flaps are adjusted and secured by sutures.

Fig. 1041.

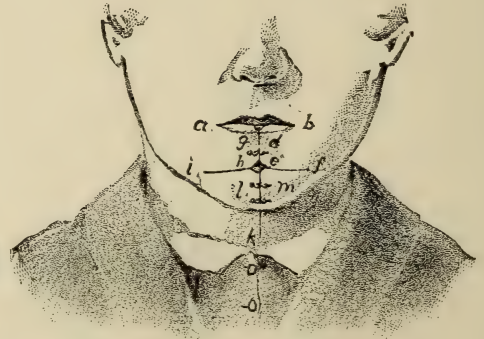
Fig. 1042.



Restoration of lower lip by another method. (After Szymanowski.)

Fig. 1043.

Fig. 1044.



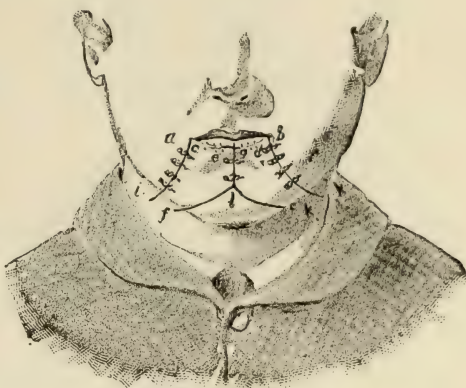
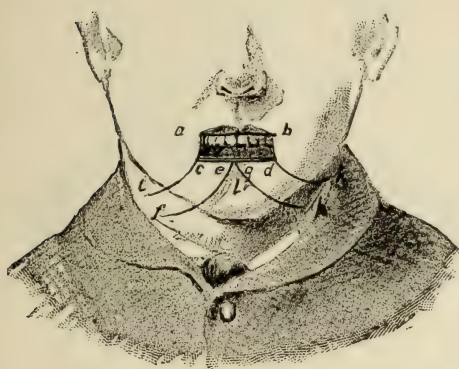
Another method of restoring the lower lip. (After Szymanowski.)

Fig. 1043 represents another mode of closing the chasm by lateral flaps on each side, with their bases above toward the cheeks, and their free extremities below. These flaps, as represented in Fig. 1044, are turned edgewise so that their free extremities meet in the median line, and the lower part of the chasm is filled by other flaps dissected from the subjacent parts.

Fig. 1045 represents a chasm of the form of a parallelogram produced by the excision of the lower lip, and two curved flaps extending below the base of the jaw, and with their upper free extremities separated by a triangular portion of integument which is left above the chin. Fig. 1046 represents these flaps as drawn up to form the reconstructed lower lip, and supported by the triangular buttress of integument which was left *in situ*.

Fig. 1045.

Fig. 1046.

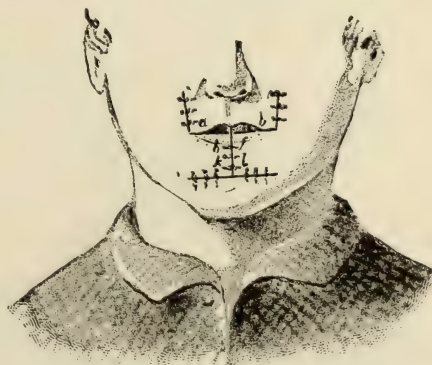


Reconstruction of lower lip. (After Szymanowski.)

Fig. 1047 represents a chasm similar to that of Fig. 1045, but with vertical flaps on each side, with their free extremities directed upward, and designed to be turned edgewise so that their free extremities shall meet in the median line, as represented in Fig. 1048.

Fig. 1047.

Fig. 1048.



Reconstruction of lower lip by another method. (After Szymanowski.)

Fig. 1049 represents a case in which the whole border of the lower lip is destroyed, but in which the loss of substance does not extend far down towards the chin. Three portions of skin are excised, each of the form of a spherical triangle, the middle one with its base upward and its apex towards the chin,

while the two lateral triangles have their bases at the commissures of the lips, and their apices directed outwards upon the cheeks. Fig. 1050 represents the reconstructed lip, the lateral flaps being brought together in the median line, and at the same time being lifted up by their attachment to the cheeks.

Fig. 1049.

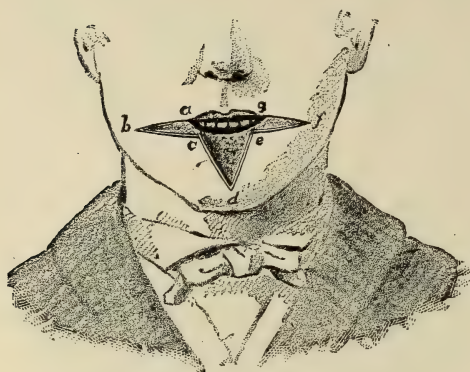
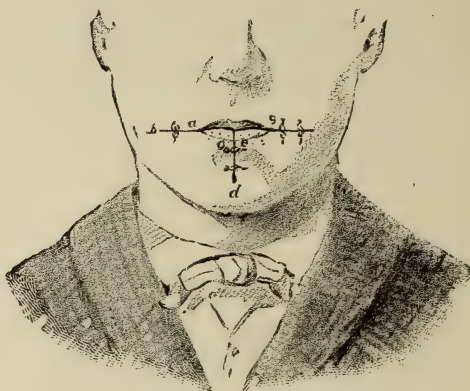


Fig. 1050.



Restoration of border of lower lip. (After Szymanowski.)

Fig. 1051 represents a much more extensive loss of substance, involving the whole breadth of the lower lip and the right angle of the mouth. To cover the deficiency, two flaps of unequal size are dissected from the cheeks, the smaller one on the right, above and without the right angle of the mouth, the larger one on the left, chiefly below and without the left angle of the mouth, and extending below the base of the jaw. The reconstructed lip and the lines of union of the flaps are seen in Fig. 1052.

Fig. 1051.

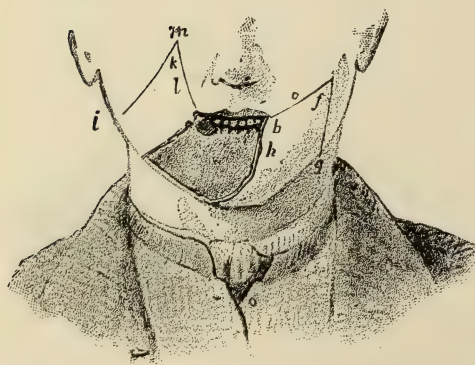


Fig. 1052.



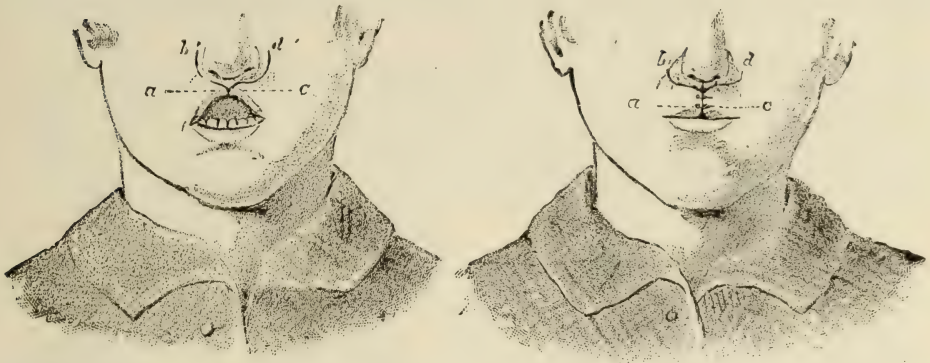
Restoration of lower lip and angle of mouth. (After Szymanowski.)

Fig. 1053 exhibits a remarkable fissure of the upper lip, in which the sides of the fissure extend in a direct line from the columna nasi to the angles of the mouth. To remedy this defect, a curved incision is carried on each side

around the ala nasi, separating the upper extremity of the border of the fissure from the columna, and the flaps thus made are brought together in the median line, in such a manner that the edges of the fissure become horizontal and form the free border of the reconstructed upper lip, as shown in Fig. 1054.

Fig. 1053.

Fig. 1054.

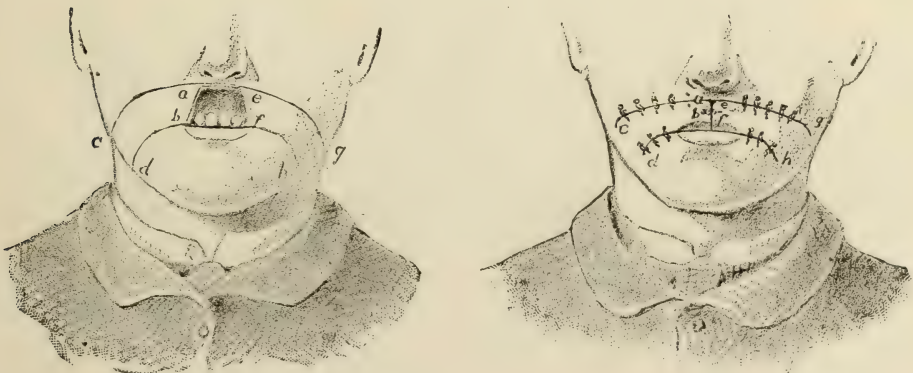


Operation for fissure of upper lip. (After Szymanowski.)

Fig. 1055 exhibits a case of destruction of the upper lip throughout its whole extent. Lateral flaps, of the full breadth of the lip, are cut on each side; their outer extremities are curved downwards so as to relieve them from tension; and their inner extremities are then drawn together in the median line, as shown in Fig. 1056. Figs. 1055 and 1056 are altered from Szymanowski's drawings by curving the peduncles of the flaps. This change in the form of the flaps is a matter of great importance in relieving tension, and in securing primary union with a minimum of deformity.

Fig. 1055.

Fig. 1056.



Restoration of upper lip. (Modified from Szymanowski.)

Fig. 1057 exhibits a cleft of the upper lip, extending from the angles of the mouth to a point in the median line, one third of the distance from the nose to the incisor teeth. A transverse incision is made above the upper extremity

of the cleft, so that the lower border of the lip can be brought down to its normal position, and from the two extremities of this transverse incision vertical incisions are carried up on each side of the nose, and then an oblique, curved incision is made upward and outward on each cheek, and from its extremity another slightly curved incision is made downward and a little outward. These incisions circumscribe a flap on each side, and these flaps are turned downwards and inwards so that their upper extremities meet in the median line, and fill up the space between the transverse incision and the

Fig. 1057.

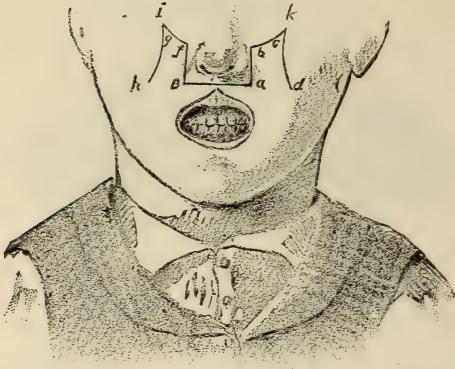


Fig. 1058.



Operation for cleft of upper lip. (After Szymanowski.)

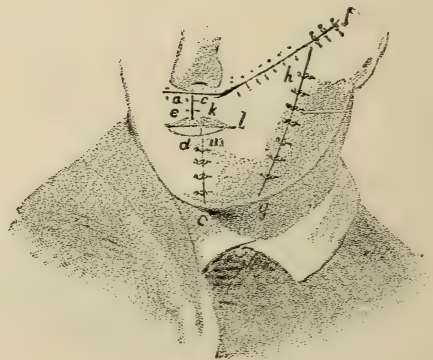
depressed margin of the lip, as shown in Fig. 1058. The acute angles at *i* and *k* favor the approximation of the edges of the wound without puckering.

Fig. 1059 represents the destruction of the whole of the lower lip, and of

Fig. 1059.



Fig. 1060.



Restoration of both lips. (After Szymanowski.)

nearly the whole of the upper lip, only a small portion of its right extremity being preserved. To cover this deficiency, and reconstruct the lips, a transverse incision is made in each cheek along the line which separates the teeth of the upper jaw from those of the lower jaw ; another transverse incision is

made on the right side below the ala nasi, and a huge flap is made on the left side, bounded within by the left border of the chasm, above by an oblique line extending upward and outward from the left upper angle of the chasm to a point in front of the left ear, and without by a curved line which extends along the ramus of the jaw below its base to the upper part of the neck. This large flap is drawn across the median line to meet the smaller flap on the right side. The vermilion borders of the upper and lower lips are made by uniting the mucous membrane with the skin, as seen in Fig. 1060.

Fig. 1061 exhibits the chasm occasioned by the removal of the right angle of the mouth and the adjacent portions of the upper and lower lips. The chasm represents two triangles joined by their bases near the angle of the mouth, the apex of the lowest triangle extending down toward the right side of the chin, and that of the upper one extending outwards towards the ramus of the jaw. Fig. 1062 shows how the sides of the triangles are approximated to restore the contour of the mouth.

Fig. 1061.

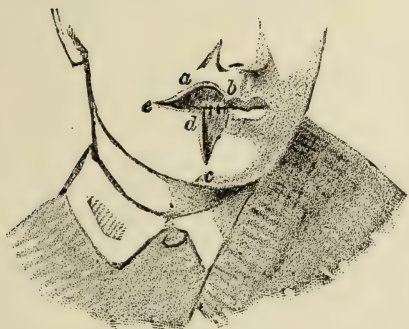
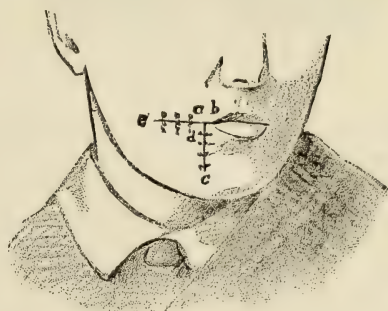


Fig. 1062



Restoration of parts of both lips and angle of mouth. (After Szymanowski.)

Fig. 1063 exhibits the lines of incision by which a diseased mass involving the middle half of the free border of the lower lip has been removed. If the sides of this chasm were simply approximated, the edge of the lower lip would be very much contracted, and the border of the upper lip would appear abnormally full. To obviate this difficulty, and to cause the upper lip to impart a portion of its superfluous border to supply the deficiency of the lower lip, a Y-incision is made transversely a little beyond each angle of the mouth, and when the lateral flaps are joined together in the median line, a portion of the border of the upper lip on each side is made to supplement the border of the lower lip, as seen in Fig. 1064.

Before concluding the subject of cheiloplasty, it may not be amiss to make a few statements with regard to the general subject of plastic operations. The success of these operations depends largely on careful attention to certain minute details. One of the most important matters in this connection is the treatment of cicatricial tissue. None of this tissue should be included in transplanted flaps, as it will almost invariably lead to sloughing of the flap. Cicatricial tissue may be freely incised, and may even be divided into narrow segments, without losing its vitality, if its basal attachments be left undisturbed. An incision may be made through a cicatricial band, and a

flap of healthy integument may be attached to it by sutures, and union will take place. In transplanting a flap of integument to fill up a chasm, great care should be taken to secure a sufficient vascular supply to maintain its vitality, by allowing ample breadth to its peduncle, and by including in the

Fig. 1063.

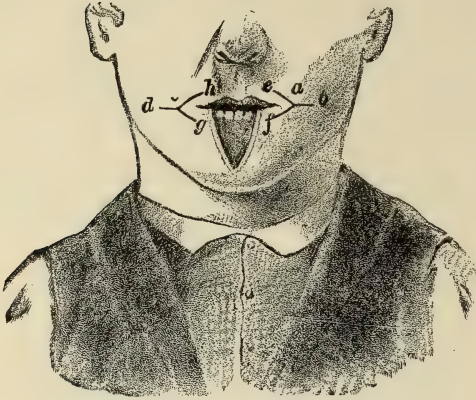
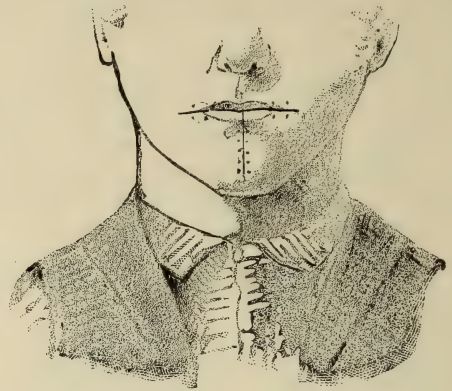


Fig. 1064.



Mode of repairing deficiency of edge of lower lip. (After Szymanowski.)

flap a sufficient thickness of subcutaneous cellular tissue. The success of a plastic operation depends very much on the absence of tension, and on the freedom with which the flaps are brought into position. When the transplanted flaps are of considerable thickness, and when they traverse an extensive space, they should be held in position by pin sutures extending through nearly their whole thickness. In addition to these deep sutures, fine silken sutures should be employed at short intervals to maintain a close union of the external lips of the wound. When a certain amount of tension is unavoidable, it may be relieved in part by the use of bead sutures, as recommended by Dr. Buck, in his work on Reporative Surgery. For this purpose, silver wire should be passed through the whole thickness of the flaps, entering on one side and emerging on the other an inch or more from their line of union; the end of the wire on one side is passed through a glass bead, and then through a small disk of leather, and tied into a knot, while the other end of the wire is passed through a bead and drawn so as to bring the edges of the wound into close contact, and then twisted over a small piece of wood, such as the end of a friction match. The end of the wire should be left long, to admit of its being readjusted if it should become too tight or too loose. When one or more bead sutures are employed to relieve tension, the edges of the wound should be accurately adjusted to each other by fine black silk stitches. While the sutures are in position, no adhesive plasters, bandages, or compresses, or any other dressings should be employed, but if the parts become inflamed, cooling and astringent lotions may be applied. After the removal of the sutures, the recently united parts may be supported by means of adhesive plasters, or of shreds of lint moistened with collodion.

After the flaps have become perfectly united, if there be at any part a superfluity of tissue, a small portion may be excised, being included between two semi-elliptical incisions, and the edges brought into contact and secured by fine sutures. Under these circumstances, union will take place more rapidly and more perfectly than if similar incisions had been made in parts whose natural relations had not previously been disturbed.

INJURIES AND DISEASES OF THE MOUTH, FAUCES, TONGUE, PALATE, AND JAWS.

BY

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UNIVERSITY COLLEGE HOSPITAL.

INJURIES OF THE MOUTH, FAUCES, AND TONGUE.

WOUNDS OF THE TONGUE caused by the teeth of epileptics are seldom severe enough to require any special treatment, but bites of the tongue caused by a fall upon the chin or a violent blow beneath the jaw, when the tongue is protruded, are often serious. The hemorrhage may be best arrested by the use of ice, or, in its absence, by exposing the part to cold air, but any serious arterial bleeding should be controlled with a ligature, which, though apt to be soon sucked off, usually sufficiently accomplishes its purpose if tied tightly. When only the margin of the tongue is bitten through, no stitches will be required, but when a large portion of the tip is hanging loose, it will be necessary to put silk sutures deeply into the substance of the tongue, in order to bring the parts into apposition. I have, on more than one occasion, had to pare the edges of a bitten tongue in which this had been neglected, and then bring the parts together again with stitches. Wounds of the tongue by the stem of a pipe or a crochet-needle, held in the mouth, occasionally occur, and a piece of broken tobacco-pipe has been found imbedded in the tongue many months after the accident. In the case of a crochet-needle or fish-hook which may have been accidentally driven into the tongue, it will be necessary to force the barbed point completely through the organ, in order that its removal with cutting-pliers may permit the withdrawal of the shaft of the instrument.

WOUNDS OF THE FAUCES may be due to accident or to surgical interference. Accidental wounds are mostly caused by the forcible thrusting backwards of a tobacco pipe, and are unimportant, unless, as has happened, the stem should have been driven obliquely outwards into the internal carotid artery.¹ In such a case the withdrawal of the stem must lead to fatal hemorrhage, and it may be doubted whether, if the injury could be diagnosed, the fatal event could be averted. A case of deep arterial wound by the point of a parasol, in which the common carotid was successfully tied, is recorded by Mr. Durham,² but it was probably some branch of the external carotid which was wounded. The hemorrhage following a puncture of an inflamed tonsil is often

¹ See cases by Mr. Vincent (*Medico-Chirurgical Transactions*, vol. xxix.), and Mr. Charles Moore (*Lancet*, Sept. 10, 1864).

² Holmes's *System of Surgery*, 3d ed., vol. i. p. 745.

severe, and depends upon a wound of an unusually large tonsillar artery; or, possibly, if the puncture has been very deep, the blood may come from the ascending pharyngeal artery. The fear of wounding the internal carotid artery by any reasonable incision is chimerical, and in fatal cases of ligature of the common carotid, for supposed wound of the internal carotid, that vessel has been found intact. Several illustrations of this statement will be found in a list of fifty cases of wound of the throat in which the common carotid was tied, appended to a paper by Mr. Harrison Cripps,¹ in which the author advocates ligature of the external rather than of the common carotid in similar cases.

WOUNDS OF THE PHARYNX by bodies swallowed, such as fish-bones, needles, pins, or pieces of grass (Moore), give rise to serious abscesses in the cellular tissue behind the pharynx. In two cases I have known *torticollis* produced by a pin which I was able to extract with a horse-hair probang.

FOREIGN BODIES, such as portions of insufficiently masticated meat, may lodge in the pharynx and give rise to serious symptoms, and even death, by obstructing the windpipe.² Unfortunately, in these cases the urgent symptoms are often misinterpreted and the patient thought to be suffering from apoplexy, for the prompt removal of the foreign body with the finger is a sufficiently obvious and simple mode of treatment. A case is recorded by Mr. Pollock³ in which a set of displaced artificial teeth caused death by being impacted in the pharynx and pressing on the epiglottis; but, on the other hand, Sir James Paget⁴ removed a large plate, with nine artificial teeth attached, from the pharynx of an old gentleman *four months* after they had been swallowed.

Tooth-plates may in most cases be withdrawn from the pharynx with ordinary curved forceps; but when they have projecting metal points, these are apt to become entangled in the wall of the pharynx and prevent withdrawal. In these circumstances it will be necessary to open the pharynx, as in two successful cases recorded by Mr. Cock.⁵ The foreign body being fixed at the point where the pharynx and œsophagus join, an incision along the inner edge of the left sterno-mastoid muscle, with its centre opposite the cricoid cartilage, will allow of a careful dissection to the inner side of the carotid sheath, until the projecting wall of the pharynx is reached. The gullet having been opened and the foreign body extracted, the opening may be advantageously closed with carbolized catgut sutures.

DISEASES OF THE MOUTH AND FAUCES.

INFLAMMATORY AFFECTIONS OF THE MOUTH AND FAUCES may be due to local or constitutional causes. A scald of the mouth from imbibing hot fluids, or hot steam (as not unfrequently occurs in the case of the children of the poor from drinking out of a teakettle), will produce a sodden condition of the mucous membrane of the mouth, with possibly vesication. Inflammatory action supervenes in due course, and may lead to fatal œdema of the larynx and fauces, but in the mouth comparatively little harm will be done except by the local destruction of epithelium, which may be seen forming a dense white membrane closely resembling that found in diphtheria.

¹ Medico-Chirurgical Transactions, vol. lxi. 1878.

² Beale, Pathol. Soc. Trans., vol. iii.

³ British Journal of Dental Science, vol. v.

⁴ Guy's Hospital Reports, 3d series, vols. iv. and xiii.

⁵ Lancet, April 3, 1869.

The imbibition of strong mineral acid or of strong carbohc acid, is usually immediately fatal from injury to the stomach, but in cases in which the fluid has been ejected, the mucous membrane of the mouth will be charred, and deep sloughing will ensue.

STOMATITIS, or inflammation of the mouth, is a disease of childhood, except when it is the result of the action of mercury upon the system. In badly fed and ill-nourished children, it is common to meet with an inflammatory condition of the mouth (*stomatitis follicularis*), coupled with small vesicles rapidly developing into ulcers. Added to this is commonly found the condition known as "thrush," due to the development of a grayish-white pellicle containing the *oidium albicans*, a parasitic fungus.

A more important form of the disease is the *stomatitis gangrenosa*, which if unchecked may develop into the formidable *cancrem oris*. Beginning usually in the gum, close to the necks of the teeth, the disease appears as a line of unhealthy ulceration, which rapidly extends along the neighboring gum, and into the sulcus of mucous membrane between the teeth and the cheek. Owing to the destruction of the gums and the extension of inflammation into the sockets of the teeth, these soon become loosened, and drop out; there is a profuse, purulent, offensive discharge, by swallowing which the patient is poisoned, besides being worn out by the irritation and want of food.

The slightest cases, whether of simple or gangrenous stomatitis, are best treated by attention to feeding, and especially to hygiene; and locally by the use of the solid nitrate of silver, and the constant application of the glycerine of carbohc acid, combined with the internal administration of chlorate of potassium, which seems to be almost a specific remedy in these cases. The more severe cases of gangrenous stomatitis must be arrested by the application of strong nitric acid or the actual cautery—by preference Paquelin's thermo-cautère—while the patient is under the influence of chloroform.

*Cancrem oris*¹ is thought by some authors to be a separate disease, and to originate in the cheek, which rapidly becomes gangrenous and sloughs away, causing a hideous deformity, and rapidly proving fatal in the majority of cases. The treatment is the same as for the more severe forms of gangrenous stomatitis, but the disease is apt to leave terrible deformity in cases which recover, and to lead to permanent closure of the jaws by cicatrices.

TONSILLITIS, or acute inflammation of the tonsils, commonly results from exposure to cold in the case of delicate young people who have susceptible throats. Towards evening the throat feels swollen and painful, and both speech and deglutition become difficult, the voice having a peculiar, thick tone, which is very characteristic. On inspection, the fauces will be seen deeply injected, and the tonsils swollen and bulging both towards the median line and behind the anterior pillars of the fauces. There is great tenderness in the submaxillary region and behind the jaw, and occasionally acute pain in the ear, from extension of inflammation along the Eustachian tube. There is, besides, considerable fever, the temperature rising three or four degrees, and the tongue being coated with a white fur; but the pulse, though rapid, has little force, and is very compressible. In from twelve to twenty-four hours, and either with or without a rigor, matter forms in one or, seldom, both tonsils; and if not relieved gives rise to great distress from the embarrassment caused to the breathing, the patient sitting up in bed and constantly hawking

¹ See Vol. I., page 802.

² Vide infra.

up viscid mucus, until at last in some straining effort the abscess bursts, when immediate relief with rapid convalescence follows.

In the premonitory or early stage, a mustard emetic often acts as a charm and produces immediate resolution; but, failing thus, recourse may be had to warm inhalations, the application of hot poultices below the ear, and the administration of belladonna internally, in small and frequent doses, coupled with plenty of liquid food. Salicylate of sodium has also been held to act as a specific in these cases. An early puncture of an inflamed tonsil is much to be recommended if the surgeon will use a bistoury covered except for a quarter of an inch from the point, and will thrust it boldly through the soft palate where it is made prominent by the tonsil. The hemorrhage should be encouraged by gargling with hot milk and water, and much greater relief will thus be given than by the application of leeches externally. The same method should be adopted in opening an abscess in the tonsil, and thus all risk of doing damage to important structures will be avoided.

A more chronic form of tonsillitis is familiar to residents in hospitals under the name of "hospital sore-throat," and is met with among persons exposed to bad air, particularly if tainted with sewer-gas. It consists in a subacute inflammation of the tonsils, with injection and ulceration of the fauces, sometimes going on to abscess, but more frequently subsiding if the patient is put upon a stimulant and tonic plan of treatment, and removed from the depressing influences to which he has been exposed. The occurrence of frequent sore-throats in a household should direct immediate attention to the condition of the drainage, and to the probable escape of sewer-gases into the house.

PHARYNGITIS.—Acute inflammation of the pharynx may occur in conjunction with tonsillitis, or alone, and its chief symptom is the difficulty in swallowing. The disease ends ordinarily in resolution, but may occasionally lead to suppuration in the cellular tissue behind the gullet, thus causing a post-pharyngeal abscess. The bulging forward of the posterior wall of the pharynx by an elastic swelling which impedes deglutition and may interfere with respiration, clearly marks the case,¹ and a puncture in the median line will readily evacuate the pus. It should not be forgotten that post-pharyngeal abscess is often connected with caries of the cervical vertebræ, in which case it has been proposed by Mr. Cheyne to open the abscess externally with antiseptic precautions.

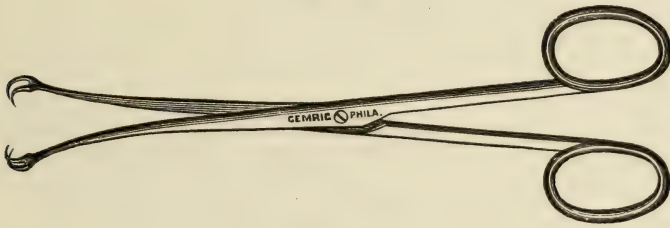
ERYSIPELAS occasionally attacks the fauces and pharynx, and appears to lead to complete temporary paralysis of the muscles, so that not only is deglutition suspended, but it is impossible to excite reflex action in the muscles by irritating the throat mechanically. The affection is a very serious one, and likely to prove rapidly fatal from depression of the vital powers, both by the poison and by the want of food, unless ample nourishment be administered by the rectum until the power of swallowing is restored. A much more chronic form of paralysis of the throat is that following diphtheria, but here it is the palate which is principally affected, the voice being thick for weeks.

HYPERTROPHY OF THE TONSILS is common in children and young persons of a strumous diathesis, and in rachitic patients is apt to lead to the deformity known as "pigeon-breast," from interference with the full expansion of the lungs. The thick speech, open mouth, and stertorous breathing, which in sleep develops into sonorous snoring, are sufficiently marked in extreme cases;

¹ C. Fleming, Cases Occurring in Children, Dublin Journ. of Med. Science, vol. xvii.

whilst in milder cases the constant tendency to sore throat and the general failure of health and strength without obvious cause should direct attention to the tonsils. On inspection, the tonsils will be seen as large, white, glistening masses, often meeting in the middle line, and presenting yellow spots due to inspissated mucous secretion. Hypertrophied tonsils may project into and down the pharynx, but can never reach up to and obstruct the Eustachian tubes; the deafness so commonly found in these cases is due to the generally congested condition of the mucous membrane, which is relieved by the removal of the glands. The application of local styptics in the form of a solution of nitrate of silver (gr. x to f $\frac{3}{4}$ j), or the glycerine of tannin; the use of catechu or krameria lozenges, or the employment of a spray of sulphate of zinc (gr. x to f $\frac{3}{4}$ j), are all useful in slight cases by keeping the disease in check, while the patient's health is improved by sea air and tonics. In severe cases, removal of the projecting portion of the tonsil is the best remedy, and is much less painful and infinitely more satisfactory than drilling the tonsil with a sharp stick of nitrate of silver, or caustic potassa, as has been recommended. The simplest form of guillotine, used with a pair of volsella forceps (Fig. 1065), by

Fig. 1065.



Volsella forceps.

which the tonsil can be drawn thoroughly into the ring with the opposite hand, is preferable to the complicated guillotines fitted with a fork, which are apt to get out of order, and which require considerable practice for their successful employment. The patient being seated in a good light, with the head thrown back and the hands held by assistants, the guillotine can be slipped into the mouth, which it immediately gags. The forceps then grasping the tonsil through the ring of the guillotine, draws it well forward, and a sharp movement of the thumb drives home the blade of the guillotine and cuts a large portion off. Without withdrawing the guillotine, it is turned round and the other tonsil is similarly treated by changing hands, before the little patient has really time to cry. It is quite sufficient to remove a large portion of a tonsil, and any attempt to remove the whole is likely to be followed by sharp bleeding; but at the same time it is necessary to pull the piece to be removed well into the ring, so as to avoid notching the pillar of the fauces, from which the mucous mem-

Fig. 1066.

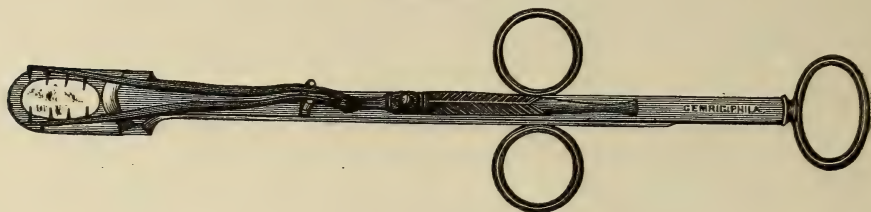


Fahnestock's tonsillotome.

brane is continued directly on to the tonsil, occasionally holding it very firmly. Ordinarily, the sucking of ice for a few minutes staunches all bleeding, but if not, the bleeding surface, and that only, should be painted with the solution

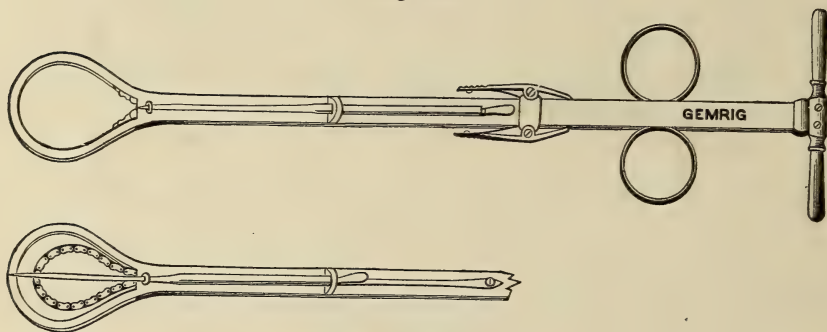
of the persulphate of iron. After removal of the tonsils, ice may be sucked for a few hours, and a warm poultice under the jaw gives great comfort. Care should be taken to give food cool enough to be easily swallowed, and for a few days hard substances, such as crusts, should be avoided. [Figs. 1066 and 1067 represent convenient tonsil guillotines, devised respectively by the late Dr. Fahnestock and Dr. Billings, U. S. A. Fig. 1068 illustrates the tonsil *écraseur* employed by Prof. Gross.]

Fig. 1067.



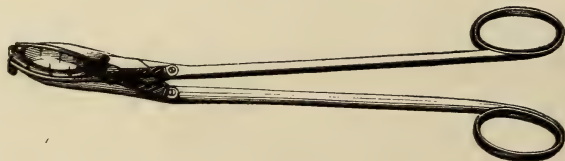
Billings's tonsillotome.

Fig. 1068.

Gross's tonsil *écraseur*.

HYPERTROPHY OF THE UVULA may be met with in the same class of patients as hypertrophied tonsils, the whole uvula being swollen from over-development of the adenoid tissue contained in it. This must not be confounded with the œdematous uvula due to inflammation, and commonly found in any acute inflammation of the throat. A more common form is the elongated uvula found in persons of relaxed habit, who suffer from irritable throat and constant cough, the result of the irritation of the fauces by the uvula. Astringent gargles may be usefully employed in such cases, but if obstinate, these should be treated like those of chronic hypertrophy, by abscis-

Fig. 1069.



Uvula scissors.

sion. This little operation may be performed with the tonsil guillotine, or more simply with scissors, which must be very sharp at the edge but blunt

at the points. The uvula should be caught with a pair of hooked forceps to prevent its being swallowed, and will be found thicker on section than might have been anticipated. [A convenient form of uvula scissors is represented in Fig. 1069.]

ULCERATION OF THE TONSILS of a superficial character is common in inflammatory affections of the throat, and the ulcers are often covered with aphthous patches in patients whose vitality is low. The deep, excavated ulcer of the tonsils, nearly circular in shape and covered with a thin gray slough, is symptomatic of secondary syphilis, and will only yield to constitutional treatment.

Irregular, excavated ulcers presenting a yellow slough, seen upon the uvula and soft palate, or on the posterior wall of the pharynx, are almost always due to tertiary or inherited syphilis, and will heal rapidly under the administration of iodide of potassium in full doses.

As the result of this form of ulceration, adhesions of the soft palate to the pharynx, with narrowing of the pharynx and nasal intonation, owing to the shutting off of the nose, are occasionally met with. Interference with the cicatrices is ordinarily to be avoided, as no good result is likely to follow the division of the adhesions between the palate and pharynx; but where the cicatrization leads to narrowing of the pharynx, division, and subsequent dilatation with bougies, may be advantageously undertaken.¹

TUMORS OF THE TONSILS, as distinguished from glandular hypertrophy, are rare. In general *lymphadenoma* of the neck, the tonsils may be similarly affected, and may in the later stages ulcerate, as in a lad of seventeen under the author's care. A few instances of distinct *fibro-cellular* tumor of the tonsil have been met with, one of the most recent being that recorded by Mr. Fitzgerald,² Surgeon to the Melbourne Hospital, which occurred in a boy of fifteen, and had been present four years, gradually blocking up the fauces. It was successfully removed, and was of irregular, ovoid form, distinctly encapsuled and lobulated. "Its measurements were: Length $2\frac{1}{4}$ inches; breadth $1\frac{3}{4}$ inches; thickness $1\frac{1}{2}$ inches. Under the microscope, sections were found, unless very thin, to have a confused fibro-cellular appearance, not cleared up at all by acetic acid. When traced out, the growth was found to consist of small cells, rounded, oval, or spindle-shaped; the spindles, as a rule, were nucleated, and the round cells destitute of nuclei." According to Butlin, round-celled *sarcoma* is the most common of all malignant tumors of the tonsil.

Cancer of the tonsil is rare; it may be primary, in which case it is encephaloid, or more rarely scirrhus; or secondary, from extension of epithelioma from the tongue and pillars of the fauces.

Cases of encephaloid cancer of the tonsils in connection with development of cancer in the lymphatic glands of the neck and in the spleen, have been recorded by Carswell, Sydney Jones, and Moxon; such cases are clearly beyond surgical treatment, but when the disease is confined to the tonsil it has been successfully removed.

Mr. Poland,³ in an exhaustive article upon "Cancer of the Tonsil Glands," shows that the diagnosis of cancer in the early stage is very difficult, it being confounded with chronic hypertrophy or syphilitic gumma. Its rapidity of growth and tendency to involve surrounding structures, including particularly the lymphatic gland at the angle of the jaw, will afterwards serve to dis-

¹ See a Case of Extreme Pharyngeal Stenosis, with *résumé* of subject, by Smith and Walsham. Medico-Chirurgical Transactions, vol. lxiii. 1880.

² Australian Medical Journal, September 15, 1880.

³ British and Foreign Medico-Chirurgical Review, April, 1872.

tinguish its nature. Removal of portions of the growth by the knife, wire-snare, and *écraseur*, have given unsatisfactory results in the hands of several surgeons, and, if any operation is resorted to, total extirpation of the tonsil should be performed. This operation, though said to have been employed by Langenbeck and Hueter, in 1865, was first described by Dr. Cheever,¹ of Boston, who performed it successfully in 1869, and again in 1878.² In both cases, the operation was done through an external incision below the angle of the jaw; and in the second case, the jaw was divided and turned up so as to gain sufficient room without dividing the digastric, stylo-hyoid and styloglossus muscles, as had been done in the first case. In both instances the tonsil, when reached by dividing the superior constrictor of the pharynx, was enucleated with less trouble and hemorrhage than might have been anticipated.

Dr. Cheever's first patient was lost sight of; in the second case the history may thus be summarized. The primary growth began in the tonsil in August. Lymphatic poisoning occurred, and a bubo formed, in November. The tumor and the bubo were removed by the knife, early in January. Early in February, a second bubo had formed and was removed. In March, the original growth was sprouting again, and was twice burnt away, the bubo not recurring. In May, the pharyngeal tumor was larger than ever, and the bubo was recurrent in an enormous growth. As Dr. Cheever remarks, "the question remains whether, in view of such rapid and persistent recurrence as in the second case, it is worth while to interfere with cancer of the tonsil at all by operation."

In Dr. Cheever's second case, and also in Mr. Fitzgerald's case of fibro-cellular tumor, already described, tracheotomy was done, and the upper aperture of the larynx was plugged to prevent the entrance of blood into the lungs; and it would appear that if this were effectually done, enucleation of the entire growth from within the mouth might be fairly attempted, the diseased lymphatic gland being dissected out separately. Mr. Fitzgerald,³ indeed, says that, had he known as much as he did afterwards, he would not have made an incision through the cheek, "for after free division of the muscles that bind the lips to the bone, the mouth can be opened to almost any extent that may be required."

In October, 1882, Mr. Golding-Bird and Mr. Clement Lucas, of Guy's Hospital, communicated to the Clinical Society of London cases of epithelioma of the tonsil, removed by the former gentleman from the outside, by Cheever's operation, and by the latter from within the mouth, portions of the soft palate and tongue being at the same time taken away. The results, though not leading to a permanent cure, were encouraging.

FOLLICULAR DISEASE OF THE PHARYNX is commonly met with as an accompaniment of chronic glandular laryngitis, or *dysphonia clericorum*. The pharynx and fauces are seen to be injected and roughened, owing to hypertrophy of the glandular structures of the mucous membrane. The patient complains of dryness of the throat, and is constantly clearing it, and hawking up small quantities of viscid mucus. The hoarseness of the voice after use for a short time is a marked feature of the disease, and depends upon a similarly congested condition of the laryngeal mucous membrane. In slight cases, much good may be done by proper elocutional instruction, and particularly by teaching the patient to use his lips and tongue rather than his throat in vocalizing. The use of soft astringent lozenges (catechu or rhatany), which are to be slowly sucked at intervals, and the use of a spray with a solution

¹ Surgical Cases, Boston, 1869.

² Boston Med. and Surg. Journal, August 1, 1878.

³ Loc. cit.

of sulphate of zinc (gr. x to f3j), night and morning, will effect much good. In more confirmed cases, the application of a strong solution of nitrate of silver (gr. xxx to f3j), with a brush, or painting with the tincture of iodine or solution of the perchloride of iron, will be necessary, combined with attention to the general health; but the improvement is always slow, and the remedies must be varied to suit individual cases.

TUMORS OF THE PHARYNX are of rare occurrence, and usually of congenital origin; they are mostly pendulous, with a narrow neck. The most remarkable case known is one in which a fatty tumor, now in the museum of the Westminster Hospital, occurred in an old man whose history is recorded by Mr. Holt.¹ Here the pedicle was attached to the epiglottis, so that when the tumor was projected into the mouth the patient was suffocated. Other cases in which smaller pedunculated growths have been successfully removed, are recorded, and in any case of difficulty from impending asphyxia, the operation of laryngotomy would relieve all embarrassment during the removal of the tumor.

A pulsating tumor of the pharynx may be due to an aneurism of the *internal carotid artery*, as in cases recorded by Porter and Syme; and Mr. Barnes,² of Bolton, has recorded a case of pulsating tumor of the back of the pharynx, in a woman aged seventy-three, in which the pulsation was entirely arrested by pressure upon the *external carotid*.

DISEASES OF THE TONGUE.

TONGUE-TIE is a common congenital affection, but more often imagined by the mother or nurse than actually present. Any slight difficulty in sucking, soon after birth, or in talking at a later period, is apt to be put down to "tongue-tie," and though in some cases the frænum is shorter, and extends nearer the tip of the tongue, than in others, it may be doubted whether, except in extreme examples, it ever really interferes with the movement of the organ. I have, however, recently had to divide the frænum in a young man of twenty-eight, whose speech was certainly interfered with. The operation of division is very simple if a blunt-pointed pair of scissors be used, and if the points be directed downwards so as not to injure the tongue itself, or the ranine artery, which may be protected with the fingers, or with the split handle of a director. A small snip is quite sufficient, and the point of the finger may tear the frænum a little farther if necessary.

RANULA is the term applied to cysts beneath the tongue, but these vary considerably in character. The simplest is a thin-walled cyst having a bluish look, and containing clear mucus. This is due to the obstruction and dilatation of one of the numerous mucous follicles of the floor of the mouth, and never to dilatation of the Whartonian duct of the submaxillary gland, which does not undergo dilatation except when its orifice is obstructed, as sometimes happens, by a salivary calculus. Occasionally a ranula is multilocular, a second cyst lying behind the superficial one.

The treatment consists either in snipping out a piece of the cyst wall with scissors, or in passing a fine seton through the cyst. The seton may be introduced with an ordinary curved needle, and should be of fine silver wire, the ends of which can be twisted, and will lie under the tongue without absorbing putrid material, as would be the case with silk. As a rule, the wire does

¹ Path. Soc. Trans., vol. v

² Lancet, October 30, 1875.

not cut its way out, and will require removal when the cyst has become obliterated.

A rarer form of cyst is the *congenital cyst* of the floor of the mouth, which contains inspissated, sebaceous material, closely resembling putty in appearance, and having an offensive, cheesy odor. Being of slow growth, it seldom gives trouble until early adult life, when an unsightly swelling below the chin is noticed externally, and the tongue is pushed up so as, in extreme cases, to interfere with speech.

This form of cyst is confined to the floor of the mouth, but often has a portion reflected around the posterior edge of the mylo-hyoid muscle, and presenting in the digastric triangle. This fact makes the treatment very difficult, as graphically described by Sir Wm. Fergusson,¹ who met with two cases of the kind, one of which he treated by excision, and the other by inducing suppuration in the cyst. In one case I succeeded in removing the cyst through the mouth, after dividing the mylo-hyoid so as to allow of the withdrawal of the portion superficial to the muscles. Should removal not be feasible, the use of a seton, passed from below the jaw through the mouth, after evacuation of the contents, would probably set up sufficient action to produce a cure. The diagnosis of these cases is always obscure, and they are usually mistaken, until opened, for examples of ordinary ranula.

INFLAMMATORY SWELLING BENEATH THE TONGUE, leading to the formation of pus which is apt to find its way between the muscles of the throat, may arise from abscess connected with a tooth, and should be opened early

HYPERTROPHY WITH PROLAPSE OF THE TONGUE, OR MACROGLOSSIA, though usually a congenital affection, is not invariably so. In some of the recorded cases it appears to have been the result of inflammation occurring in early life, and in one case to have followed the application of a leech. It has been regarded by some surgeons as primarily a prolapse due to deficiency of muscular power, and by others as an hypertrophy leading to prolapse by the weight of the organ; and undoubtedly, in the later stages, the whole organ is enormously enlarged and hangs out of the mouth. In Dr. Humphry's² case, in a girl aged eleven, the prolapsed portion of the tongue measured from the upper lip to the tip three and one-half inches, and the circumference of the widest part of the organ was six and one-half inches. The papillæ were greatly enlarged and separated by deep clefts, but no record is given of the condition of the portion removed. Mr. H. Arnott³ has, however, recorded a case in which there was actual hypertrophy of the muscular substance, as well as enlargement of the bloodvessels and lymphatics, and thickening and induration due to inflammation. In addition to the discomfort caused by the prolapse, in all the recorded cases an alteration in the position of the teeth and alveolus of the lower jaw, due to the constant pressure of the tongue, has been observed. In the treatment of this affection, pressure by bandaging and the use of styptics seem to have given good results in some cases, and Syme⁴ speaks highly of the use of a solution of sulphate of copper (ʒj to fʒj). Failing to get relief in this way, removal of the protruding portion with the knife, as in Syme's and Humphry's cases, or with the *écraseur*, as in Erichsen's, offers the only method of treatment available.⁵ In the case of an idiot boy, aged ten, recently under my care, with macroglossia of congenital origin, I removed the anterior portion of the tongue by a

¹ System of Practical Surgery, p. 514.

² Medico-Chirurgical Trans., vol. xxxvi.

³ Path. Soc. Trans., vol. xxiii.

⁴ Observations in Clinical Surgery. 1861.

⁵ List of cases in F. Clarke's Diseases of the Tongue, p. 72.

V-shaped incision, bringing the two sides together with stitches; but these soon cut through, and the result, though eventually satisfactory, was not better than that gained by the simpler method.

ATROPHY OF ONE SIDE OF THE TONGUE is never a congenital affection, but the result either of cerebral disease or of injury to the hypoglossal nerve, as in a case of aneurism of the external carotid artery, recently under my care, in which the nerve was stretched and atrophied.¹ Sir James Paget² has recorded a case in which removal of necrosed bone from the skull relieved the nerve and led to restoration of the tongue, but this is a favorable result which can seldom be anticipated.

NÆVUS OF THE TONGUE is another congenital affection occasionally met with. If superficial it may be treated with nitric acid, the tongue being previously dried and held out of the mouth with a towel so as to prevent injury to the surrounding parts. In more extensive nævi, the application of a ligature, which must be passed into the substance of the tongue and tied very firmly, is the best mode of treatment.

CONGENITAL TUMOR OF THE TONGUE.—A very rare form of congenital tumor of the tongue is recorded by Dr. Hickman³ as occurring in a new-born child, who died a few hours after birth from suffocation induced by the tumor. Immediately in front of the epiglottis was a tumor projecting half an inch from the surface of the tongue, and measuring three-quarters of an inch by one-half inch. It proved to be an hypertrophy of the normal racemose glandular structures of the part. Congenital fibro-cellular tumors of the tongue are occasionally met with, and, being usually pedunculated, are easily removed. Mr. F. Mason has recorded two examples of the kind, which were allowed to remain *in situ* till adult life.⁴

LYMPHANGEIOMA is a very rare congenital affection of the tongue, and is a variety of hypertrophy in which the lymphatics are principally affected. In 1876, I had a young woman aged twenty-three under my care, suffering from this affection, the tongue being enlarged and indurated so as to interfere with speech, but not being prolapsed, and the surface being tuberculated and marked with whitish lines which were evidently enlarged lymphatics. With the hope of producing some effect I passed setons into the tongue, the only result of which was to set up severe inflammation with great temporary distress of breathing, but without any permanent benefit.

GLOSSITIS, or inflammation of the tongue, in the acute form, is an affection rarely met with at the present time, and then is apparently of spontaneous origin. In former days, when the administration of mercury was ordinarily pushed to salivation, the occurrence of glossitis was common, and the swollen tongue protruding from the mouth was looked upon as a proof of successful treatment. As some individuals seem to be peculiarly liable to be rapidly affected by small doses of drugs, it may be well to bear in mind that iodide of potassium and its allies, no less than mercury, may rapidly induce salivation. The swollen, oedematous condition of the tongue in glossitis, may interfere with respiration sufficiently to demand tracheotomy, but as a rule the inflammation rapidly yields to leeching, or to a free incision on each side of the median line.

¹ Medico-Chirurg. Trans., vol. lxvi.

³ Pathological Society's Trans., vol. xx.

² Clinical Soc. Trans., vol. iii.

⁴ Ibid., vols. xv. and xviii.

In milder cases, the use of chlorate-of-potassium and borax gargles, and the free purgation of the patient, will give relief.

ABSCCESS OF THE TONGUE.—Abscess is not unfrequently the result of glossitis, and should be opened as soon as the presence of matter can be detected. In all inflammatory affections in which the tongue is protruded beyond the jaws, the effects of the presence of the incisor teeth upon the organ must be borne in mind, for a deep groove is apt to be cut in the under surface of the tongue by the teeth, and thus the swelling and œdema are increased. The teeth may be conveniently guarded by a metal or gutta-percha shield, and, if necessary, a support for the tongue may be easily adapted to such a contrivance.¹

GUMMATA OF THE TONGUE.—Closely resembling abscess, since in its later stages it breaks down and contains fluid, is the *gumma* due to tertiary syphilis. Situated near the base or in the centre of the tongue, gummata or muscular nodes slowly increase in size without pain, and then, when the patient has got out of health from the syphilitic poison in his system, they rapidly soften and discharge, leaving deep excavated ulcers.² A very similar nodule occurring in the tongue of a strumous child, and running much the same course as a gumma, would by some surgeons be considered tubercular in its origin, but it may be doubted whether most of the recorded examples are not cases of inherited syphilis. The occurrence of *fibro-cellular* or *fibroid tumors*, or of *scirrhus* or *medullary cancer*, in the substance of the tongue, is extremely rare, and as it is impossible to diagnose their nature in an early stage, it is safer to look upon all tumors of the substance of the tongue as gummatus, and to treat them with full doses of iodide of potassium. The great majority will be found to disappear rapidly under this treatment, and certainly no harm will be done by the drug in cases of other forms of growth, which are not amenable to its influences.

CHRONIC GLOSSITIS, leading to serious alterations in the superficial structures of the tongue, may be due simply to too stimulating food or drink, or, much more frequently, to the over-use of tobacco. It may also depend upon syphilis, or may be caused by prolonged mercurial treatment. In the early stage, the tongue is reddened and irritable, being much more sensitive than in health, and, possibly, patches of similarly affected mucous membrane may be found in the cheeks. If unchecked, patches of white, hypertrophied epithelium will be formed over the most irritable spots, and these may be thrown off from time to time, constituting the so-called *psoriasis lingue*.

The treatment of this chronic form of glossitis consists in removing all sources of local irritation, and in attending to the general health. Frequent painting with a five-grain solution of chromic acid, in the non-syphilitic forms, and with a two-grain solution of bichloride of mercury in the syphilitic forms of the disorder, seems to be useful, combined with the use of demulcent lozenges, slowly sucked.

A more serious result of chronic glossitis is the formation of a permanent *white patch* (*leucoplakia*, *leucoma*) in which destruction of the papillary structure is brought about with more or less infiltration of granulation-cells. These patches may remain quiescent for years, and may then develop true epithelioma, and they are therefore always causes for anxiety and watching, with a view to early operative interference should any growth begin to develop. It is remarkable, as pointed out by Hutchinson, that we do occasion-

¹ Lancet, January 22, 1881.

² Vide infra.

ally see patches on the tongue and cheeks in association with non-syphilitic skin-diseases, viz. psoriasis and pityriasis.

ALTERATIONS IN THE CUTICLE OF THE TONGUE are likely to attract attention in an early stage, and their prompt recognition and treatment are important. Before examining the surface of a tongue, care should be taken to dry it thoroughly, since the presence of saliva masks many of the characteristic appearances.

The ordinary furred, red, or glazed tongues, which are only evidences of gastric irritation or general fever, can hardly be considered surgical, but when one side of the tongue only is covered with "fur," there must be some local cause for irritation, which will probably be found in a decayed molar tooth of the upper jaw. Hilton¹ has shown that occasionally a one-sided, furred condition of the tongue, may be symptomatic of injury to the fifth nerve in fracture of the base of the skull.

Mucous tubercles of the ordinary flat form are occasionally met with on the tongues of prostitutes, and others suffering from secondary syphilis, and in these cases confirmatory evidence will be found about the lips and inside the cheek. A *warty condition* of some of the papillæ of the dorsum of the tongue, occasionally occurs in perfectly healthy children and adults, and is best treated by paring down the growth and applying nitrate of silver.

True *papilloma* occurs occasionally upon the dorsum of the tongue, consisting in a patch of thickened mucous membrane covered with hypertrophied and prominent papillæ. In its early stage it is quite superficial, and may be readily removed with the knife, but at a later period it is apt to invade the deeper layers of the corium, and to present an appearance closely resembling epithelioma, but without any lymphatic enlargement. Possibly, in some of the successful cases of removal of portions of the tongue for epithelioma, the disease really may have been papilloma.

A *loss of epithelium* in patches on the dorsum of the tongue, by which a smooth, bluish surface is left, undergoing no alteration for many weeks together, is generally due to syphilis, and may be combined with a fissured and scarred condition of the sides and tip of the organ. There is a form of smooth tongue which is apt to end in cancer, but here the loss of epithelium is more uniform and extensive, and there is submucous induration. This latter form has been specially investigated by Mr. Butlin,² who regards the disease as a chronic inflammation of the mucous membrane, and not the result of cicatrization, but probably allied to psoriasis and ichthyosis; this view, however, is contested by Mr. Jonathan Hutchinson.

A more formidable condition is that known as *ichthyosis linguae*, in which not only is the epithelium hypertrophied, but the papillæ are greatly enlarged, the surface of the tongue being rough, hard, and fissured. This is a chronic affection, lasting for many years, but tending eventually to develop into epithelioma. Mr. Hulke,³ who originally described the disease, says: "Ichthyosis is characterized by tough, white, raised patches on the surface of the tongue. Their color is not unlike that of a thin film of boiled white of egg, or wet kid leather. They are clinically distinguishable from syphilitic condylomata by their thick epithelium and their wide superficial extent; and from syphilitic nodes and cancerous tumors by their restriction to the mucosa, by their exact circumscription, by the natural softness of the underlying muscular tissue (showing the absence of infiltration), and by the absence of ulceration and of infection of the lymphatics."

¹ Lectures on Rest and Pain.

² Medico-Chirurgical Transactions, vol. lxi.

³ Transactions of the Clinical Society, vol. ii.

The prominent patches may be reduced by paring or by excision, but the disease tends to run so surely, though slowly, into epithelioma, that early and complete removal of the affected portion of the tongue should be urged upon the patient before positive evidence of cancer is developed.

ULCERATION OF THE TONGUE may be simple, syphilitic, tubercular, or cancerous.

The SIMPLE ULCER is often caused by the irritation of a sharp tooth or the end of a cigar; or it may be due to dyspepsia. It is small and superficial, and, unless due to local irritation, is generally multiple, and is often found beneath the tongue. It is painful, and interferes with the movements of the tongue, but yields readily to treatment. The removal of the sharp corner of a decayed tooth with a file, or the employment of an amber mouth-piece, and the subsequent application of a stick of nitrate of silver to the ulcer, are generally sufficient to effect a cure, when the cause is local. When it is constitutional, a brisk purge with the local use of the glycerine of tannin, or any astringent gargle, will be sufficient treatment.

SYPHILITIC ULCERATION may appear during the secondary stage of the disorder along the edges of the tongue, and will almost always be found to have a corresponding white patch on the mucous membrane of the cheek. These ulcers have no induration at their bases, but when healed leave an irregular fissured border, which is very characteristic. A later form of ulceration is found in fissures of the dorsum, which leave irregular furrows in healing.

The deep syphilitic ulcer is due to the breaking down of a gumma, and it is this kind which is apt to be confounded with cancerous ulceration. The ulcer is irregular, with everted edges, and presents a yellowish slough at its base, in which a varying amount of induration can be detected. It is often in the central portion of the tongue, whereas epithelioma is more commonly at the sides; and careful investigation will show that a lump has been noticed in the organ before the ulceration commenced, and that the induration diminishes as the ulcer grows; whereas in cancer the induration follows the ulcer, and steadily increases in extent. Still, it must be admitted that cases occur in which it is impossible to give an accurate diagnosis without having recourse to the tentative administration of iodide of potassium, and that even then it is not always possible to be sure that epithelioma has not begun in an old tertiary lesion. Recourse may be had with advantage to the microscopic examination of scrapings from a doubtful ulcer, when epithelial elements characteristic of epithelioma may possibly be obtained.¹

In the treatment of syphilitic ulceration of the tongue, regard must be had to the stage of syphilis in which it occurs, and to the previous treatment undergone. In the superficial form of ulceration, mercury, in the shape of the bichloride or the iodide, is much more effectual than the alkaline iodides alone, and should be had recourse to, unless the patient's health has been shaken by previous courses of the drug. In the tertiary form of ulcerated gumma, iodide of potassium will certainly effect a rapid cure if the ulceration is recent, provided it be given in sufficient doses, beginning with not less than 10 grains, thrice daily, and being increased to 30-grain doses, if smaller ones are not effectual. In all forms of syphilitic ulceration the local application of mercury is useful, but it must be applied, not in the form of gargles, which are used and spat out at once, but as a lotion, to be held in the mouth for five minutes, so as to "pickle" the tongue. A lotion containing the bichloride of

¹ See a paper, with drawings, by Mr. H. T. Butlin. *British Medical Journal*, Feb. 18, 1882.

mercury, gr. ss to f3j of water, with a little glycerine or honey, is a very good preparation, and its strength may be increased after a time with advantage. Care must, of course, be taken that none of the fluid be swallowed.

TUBERCULAR ULCERATION occurs, for the most part, at the tip of the tongue. At first superficial, and often multiple, the ulcer is apt to spread into the organ, leading to a splitting of the tip, which becomes bifid as the ulceration proceeds. This form occurs in patients who are distinctly tubercular, or on the border-land of tuberculosis; and the tongue improves if the general health can be reëstablished, or becomes more deeply excavated *pari passu* with the progress of the disease of the lungs or other organs. Locally, I have found benefit from the use of weak lotions of chromic acid, and have fancied that capping the lower incisor teeth with gutta-percha, so as to obviate the constant friction of the ulcer, has done good. Mercurial and all anti-syphilitic remedies are extremely harmful to cases of tubercular ulceration.

CANCEROUS ULCERATION is always of the epitheliomatous type. Attacking the side of the tongue, in patients usually over forty years of age, the onset of the disease is so insidious as to attract little attention, the ulcer being often attributed (and perhaps correctly as to origin) to the irritation of a tooth. When well developed, the ulcer is usually oval in shape, with sharply cut edges, and a marked induration beneath it when the parts are grasped by the finger and thumb. The pain of cancerous ulceration is a well-marked and early symptom, being lancinating and acute, and shooting up into the ear. The irritation causes a great flow of saliva, and the tongue is moved with difficulty, at first because of the pain produced, and afterwards because it is bound down by the infiltration of all the structures. The submaxillary lymphatic glands become involved early in the disease, being at first swollen and tender, and subsequently apt to suppurate and break down, causing large openings beneath the jaw. Should the disease spread towards the base of the tongue, death may occasionally follow hemorrhage from one of the lingual arteries, but in cases where the anterior part of the tongue is involved, this not unfrequently becomes adherent to the incisor portion of the lower jaw, and the disease ultimately infiltrates that bone. In these cases, the patient has generally a longer life, but one of great misery, and dies at length exhausted by pain and discharge, from numerous open sores about the chin and angles of the jaw.

In the *treatment* of epithelioma of the tongue, all surgeons of experience are agreed as to the inutility of medication, whether topical or general, and the advisability of early and complete removal of the disease. A recent discussion at the *Société de Chirurgie*,¹ of Paris, has shown that all the leading surgeons of that city are agreed with those of other countries, that the administration of iodide of potassium in true epithelioma is useless, and that the constant application of nitrate of silver is harmful. The difficulty in practice is to induce a patient to take a sufficiently grave view of his case at an early stage, when an operation may be undertaken with advantage, and with a fair prospect of relief, prolonged if not permanent. In the later stages, when the lymphatic glands are involved, it becomes a question whether any interference is advisable, and many surgeons would refuse an operation; but it appears to me that in many, even of the worst cases, temporary relief may often be given by operating, provided that the patient is prepared to run the immediate risk of the proceeding, which is undoubtedly great; and Mr. Stokes, of Dublin, has recently brought before the Clinical Society of London, cases

¹ Medical Times and Gazette, January 8, 1881.

in which he had removed the enlarged and infiltrated lymphatic glands with good results. Really, life prolonged in misery is worse than death following close upon the operation, and I have been thanked more than once by dying patients for having given relief during the few days for which they survived. Anæsthetics, moreover, have robbed operations of so much of their horror, that patients may nowadays be induced to submit to extensive mutilations which would have been impossible, or at least unadvisable, without chloroform. Chloroform is necessarily the anæsthetic to be employed in operations upon the tongue, for ether is inadmissible, first because of the difficulty of keeping the patient under its influence when atmospheric air necessarily gains free admission; and secondly because if, as often happens, a cautery is required in the course of the operation, a dangerous explosion and conflagration in the patient's mouth, may be caused by the inflammable vapor of the ether.

Ligature of the lingual artery has been advocated by both Demarquay and Moore,¹ in order to check the growth of cancer of the tongue, as well as for the arrest of hemorrhage, but has not yielded the results anticipated. I have on two occasions tied the lingual artery, once for hemorrhage occurring in the course of a case of cancer, and once with the view of checking the growth which was rapidly extending, but in neither case did the ligature appear to have any influence in staying the course of the disease.

Division of the lingual nerve is another palliative operation, recommended by Hilton and Moore, and this certainly is efficacious, for a time at least, in relieving the pain of a cancer involving the side and tip of the tongue. The operation is not a difficult one, and has the negative advantage of doing no harm if it effects little good. The operator feels for the mylo-hyoid ridge of the lower jaw, immediately below the last molar tooth, and a sharp-pointed curved bistoury, pushed through the mucous membrane at this point, will readily divide the nerve against the lower edge of the ridge, with little or no bleeding. The side of the tongue will be thoroughly numbed for some days, and then sensation slowly returns from union of the divided nerve, when the operation may be repeated.

Removal of portions of the tongue with the knife is an operation which has fallen into disuse, owing to the hemorrhage ordinarily accompanying it. Sir William Fergusson, who advocated the practice, and who thus removed more than one-half of the tongue in the case of the late Dr. John Reid, maintained that the fear of hemorrhage in these cases was exaggerated, and in his account of that particular operation, says:² "The bleeding for a minute or two looked formidable; several vessels were speedily secured, and there was no further trouble in this respect." It must be noted that the operation was performed without an anæsthetic, the patient being a man of great moral courage and physical endurance, and that only one lingual artery was divided. With an unconscious patient in whom both arteries have been divided far back, I have seen the very greatest difficulty arise in securing the vessels, which play across one another, and obscure the operator's view in the dark cavity of the throat.

In such cases, and in cases of secondary hemorrhage after removal of large portions of the tongue, I have found that it is practicable to arrest all bleeding in the following way. The fore-finger, passed well down to the epiglottis, is made to hook forward the hyoid bone, and drag it up as far as practicable towards the symphysis menti. The effect of this is to stretch the lingual arteries so as to completely control for the time the flow of blood through them, and in this way portions of the anterior part of the tongue

¹ Medico-Chirurgical Transactions, vol. xlv.

² System of Practical Surgery, p. 517.

may be cut off almost bloodlessly. Mr. Walter Whitehead, of Manchester, has adopted the use of scissors only, for the removal of the tongue, drawing the organ well forward, and dividing the tissues beneath by a series of snips on alternate sides, each lingual artery being secured as soon as divided.

The *ligature*, formerly used for strangulating portions of the tongue, has fallen into disuse because of the practical difficulty of keeping it sufficiently tight to insure continuous strangulation of the part to be removed, and also because of the suffering caused by the presence of a sloughing mass of tissue in the mouth. It is unnecessary therefore to consider the various modes devised for applying the ligature in former years.

The *écraseur* has been extensively employed for removal of portions, or the whole, of the tongue, with very satisfactory results. The wire *écraseur* (Fig. 1070) answers the purpose better than the chain instrument (Fig. 1071) at

Fig. 1070.

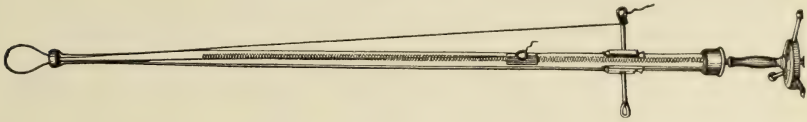
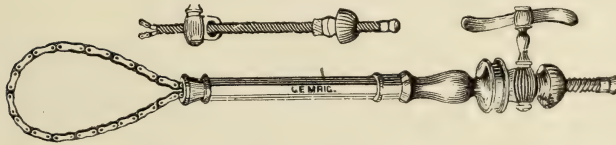
Wire *écraseur*.

Fig. 1071.

Chain *écraseur*.

first employed, in which portions of the tongue were apt to be twisted up. In order to effectually remove a diseased portion of the tongue with the *écraseur*, it is necessary to isolate the growth by passing well beyond it curved needles set in handles, around which the wire of the *écraseur* may be passed and be thus kept in its proper position. Without this precaution, the wire as it is tightened is certain to encroach upon the disease, and lead to an incomplete operation, and no forceps are sufficient alone to obviate the occurrence.

The *galvanic écraseur*,¹ used in the same way, has the advantage of cutting more readily through the tissues, which it sears at the same time, thus preventing all hemorrhage at the moment. It has however the drawback that the separation of the slough necessarily formed by the cautery, is very apt to lead to secondary hemorrhage some days after the operation, and hence the use of this instrument has been abandoned by many surgeons who formerly employed it.

*Paquelin's thermo-cautère*² is a very convenient instrument for removing small portions of the tongue, since it is not necessary in using it to pass pins beyond the growth. It is liable however to the same drawback as the galvanic cautery, viz., secondary hemorrhage.

Removal of one-half of the tongue is an operation yielding satisfactory results, and comparatively easy of performance. It was recommended by Dr. Buchanan, of Glasgow, who however divided the symphysis menti, a com-

¹ See Vol. I. page 530, Fig. 94.

² See Vol. I. page 510, Fig. 77.

plication which is unnecessary in the majority of cases, as shown by Mr. Morrant Baker.¹ A thread being passed through each side of the tip of the tongue, and the mouth gagged, the operator divides the frænum linguæ and subjacent muscles with curved scissors, which he runs along the floor of the mouth on the diseased side, so as to divide the mucous membrane near the jaw, as far back as the disease reaches. Taking one thread in his left hand, and the other being held by an assistant, the operator then with a blunt-pointed straight bistoury divides the tongue strictly in the median plane, being particularly careful to divide the tough corium of the dorsal aspect well beyond the disease. Any bleeding vessel on the surface of the section is easily seen and secured, and with the fore-finger the operator then tears through any remaining muscular structure of the tongue or sublingual tissues, so as to isolate the half of the tongue to be removed. The wire loop of the *écraseur* can then be easily slipped over the apex of the tongue to the base, through which, if necessary, needles may be inserted, and the diseased half of the organ removed as far back as may be desired. Should the disease be so extensive as to require removal down to the hyoid bone, it may be necessary to resort to the plan suggested by the late Mr. Collis, of Dublin, viz. to lay open the cheek by a horizontal incision carried from the angle of the mouth. This would of course bring the parts more thoroughly into view, but with the drawback of increased hemorrhage and permanent deformity. By employing an *écraseur* with the end slightly curved, I have been able, in several cases in which I have removed half the tongue, to dispense with any external incision.

Removal of the whole breadth of the tongue may be readily performed with the *écraseur* when the disease involves only the anterior portion of the organ, but when it extends further back, free division of the sublingual tissues, as recommended by Sir James Paget, will be necessary, in order to allow of the satisfactory application of the wire-loop to the base of the organ. Mr. Baker has recommended that, in cases requiring removal, the tongue should be split, and the halves removed by two *écraseurs* simultaneously, and both methods are for all practical purposes identical. Nunneley's method of applying the *écraseur* for removal of the entire tongue is as follows: An incision is made in the median line, between the chin and the hyoid bone, and is carried up between the genio-hyo-glossi muscles into the mouth, the chain of an *écraseur* being then carried through this. The base of the tongue being next transfixed from above downwards by three pins, the chain is passed behind them, and the *écraseur* is worked from beneath the chin. The objection to this method is that the tongue is necessarily cut obliquely, notwithstanding the use of the pins. Its advantage is that a useful drain for discharges is maintained from the floor of the mouth. Mr. Barwell has modified Nunneley's² method by making a small supra-hyoid wound, and carrying a thread into the mouth by means of a handled needle much farther back than in the older method. The needle is made to enter the mouth close to the last molar tooth on each side, and the wire of the *écraseur* is drawn by the thread through the supra-hyoid wound and around the base of the tongue. A handled needle is then passed from before backwards through the tongue at the point where the section is to be made, and the wire slipped behind it. When the tongue has been thus divided transversely, a second *écraseur* is applied in the mouth to divide the sublingual tissues which have been left. Mr. Barwell claims for this method that it leaves a painless stump, because the lingual-gustatory nerves are divided close to the lower jaw; but this result is not peculiar to this particular operation, which does not appear to possess any special advantages over

¹ Lancet, vol. i. 1880.

² Lancet, April 19, 1879.

that in which the sublingual tissues are divided before the section of the tongue, whilst if hemorrhage should occur on completion of the section of the tongue, that organ would be very much in the way of the application of a ligature.

Mr. Barwell has introduced into practice a form of wire for the *éraseur* which promises to be very serviceable. It consists of a strand of Newall's patent wire rope, made of untempered steel, with a thread in its centre, and is more flexible than any steel wire.

Regnoli, in 1838, devised a *submental operation* which consists in dividing the floor of the mouth close to the lower jaw, from one facial artery to the other, so as to allow of the tongue being drawn down and fully exposed. It may then be removed with the knife or *éraseur*; but if the knife be employed, care should be taken to divide only one lingual artery at a time. I have assisted in the performance of this operation more than once, and think that for slight cases it is an unnecessarily severe proceeding, and has no advantage over the intra-buccal method; while for the more serious cases in which it is necessary to go close to the hyoid bone, it has the drawback that the surgeon is working in a hole where it is very difficult to see and secure a bleeding artery.

Sédillot and Syme were the first to *divide the lower jaw* in order more thoroughly to extirpate the tongue. The operation is a very severe one, but affords the only satisfactory method of dealing with cases of extensive disease of the tongue, in which the floor of the mouth is involved. An incision in the median line of the lower lip, prolonged to the hyoid bone, will allow of the dissection of the lip from the lower jaw for about a quarter of an inch on each side. With a drill the bone can then be perforated on each side of the median line, and about midway in the depth of the jaw, so as to admit of the two halves being subsequently drawn together with wire. The jaw is next to be divided exactly in the median line with a fine saw, which may advantageously have its handle raised above the level of the blade, so as to be out of the way of the patient's chest. The advantage of dividing the bone in the median line is that the teeth are not interfered with, whereas in Sédillot's method of dividing the jaw by a γ cut, it is necessary to sacrifice all the incisor teeth. In addition to the wire employed to bind the halves of the jaw together, the action of the muscles tends to maintain the parts in relation and to press the halves of the jaw together, rendering the notching of the bone an unnecessary complication. If the section be completed with the bone-forceps when about half the thickness of the bone has been divided with the saw, the slight irregularity thus produced assists also in maintaining the parts in apposition. The halves of the jaw being held asunder with hooks, the operator cuts the genio-hyo-glossi muscles from the jaw with a pair of scissors, leaving the attachments of the genio-hyoid muscles. With the forefinger and scissors, the tongue can then be dissected up from the floor of the mouth, with the sublingual glands and mucous membrane, until the hyoid bone is reached, firm traction being made with a stout string passed through the tip. The tongue being then drawn down, the palato-glossi muscles forming the anterior pillars of the fauces will be put on the stretch, and must be divided with scissors, after which a handled needle should be passed through the tongue close to the hyoid bone, and the wire of the *éraseur* then adjusted.

The surgeon should be prepared with a handled needle and stout thread, to transfix and hold the small remnant of tissue left attached to the hyoid bone, should the breathing be embarrassed by the epiglottis and base of the tongue falling backward. In my experience this is much more likely to happen when a considerable portion of the tongue is left, than when the section is made far back, and the difficulty seems to arise from the weight of the piece

left, forcing back the epiglottis when the sublingual muscles have been divided.

All hemorrhage having been checked, the two halves of the jaw are to be brought together with a piece of stout silver wire. This may be passed from before backwards readily enough through the hole in one side of the jaw, but it is not easy to pass it back again on the opposite side, unless a loop of thin wire be passed from before backwards through the hole already made, into which the end of the wire can be bent, and thus drawn forward. The two halves of the jaw should be brought into close and correct apposition, and the ends of the wire twisted and brought up beneath the lip. The lip is then to be brought together with hare-lip pins, and a fine silk stitch in the mucous membrane, but care should be taken to leave the lower part of the incision open, so that there may be a free drain for the saliva and discharges from the mouth. In removing the wire from the jaw, at the end of three weeks or more, it will be found convenient to cut the wire close to the jaw on each side, and then with a blunt hook to pull out the loop from behind. When the disease involves the anterior part of the tongue, it is by no means uncommon to find the tongue adherent to the incisive portion of the jaw, and the bone more or less infiltrated, as shown by the loosening of the teeth and softening of the bone. Under these circumstances, it is necessary after clearing the bone to apply the saw on each side of the diseased portion, as far from the median line as may be necessary to reach healthy bone. After removal of the portion of bone with the diseased tongue, it is quite useless to attempt to wire the remaining portions of the jaw together, since it is impracticable to draw them in apposition at the time. And yet it will be found, in a few weeks, that as the wound heals the two sides of the jaw are gradually approximated by the action of the muscles, and will eventually in many cases unite firmly.¹

In all operations for removal of the tongue, it is well to be prepared for unexpected hemorrhage, which may be very urgent. Blood collecting in the pharynx may embarrass the breathing very much, and, by the congestion produced, keep up venous bleeding. Under these circumstances it is well to perform laryngotomy at once, and if blood has entered the lungs, as is very apt to happen when the tongue is dragged forward, to suck out the blood through the tube. I have twice seen patients rescued from imminent danger of suffocation in this way, and ultimately make good recoveries.

With the view of obviating all risk of suffocation during the operation, and also to facilitate the administration of the anæsthetic, recourse may be had, before commencing the operation of removal of the tongue, to laryngotomy or tracheotomy, and the use of *Trendelenburg's tampon*. This consists of an India-rubber tube, which covers the tracheal canula, and which can be inflated so as to plug the trachea and prevent the admission of blood; but an equally satisfactory method is to plug the pharynx with a sponge to which a string has been attached. A flexible tube attached to the ordinary tracheal canula allows of the ready administration of chloroform vapor. I have employed this method on one occasion, and have seen it employed on others, but it appears in most cases to be an unnecessary complication.

The *after-treatment* of cases of removal of the half or entire tongue, consists in maintaining the strength of the patient by judicious feeding, and in keeping the mouth sweet. Feeding is best accomplished with the ordinary earthenware feeder, having a spout to which an India-rubber tube may be fitted, if it is necessary to carry the food very far back. In this way, sufficient milk, beef-tea, and brandy may be administered until the patient pre-

¹ For cases, see *Lancet*, vol. i. 1876.

fers to take nourishment from a cup, which he often does earlier than might be expected. Should the feeding by the mouth be insufficient, recourse should be had to nutrient enemata.

With regard to cleanliness and prevention of fœtor, it is very desirable that at the time of the operation all divided tissues should be thoroughly mopped with a forty-grain solution of chloride of zinc, or be freely powdered with Iodoform, either of which applications not only obviates fœtor, but tends powerfully to prevent the absorption of septic matter. The frequent washing out of the mouth with a lotion of permanganate of potassium or lime (the latter by preference), is most readily accomplished with a siphon douche fitted with a soft-rubber nipple, which the patient can direct himself without risk of hurting the mouth. After each washing, the mouth should be brushed out with the glycerine of carbolic acid or "terebene," either of which answers admirably in preventing fœtor.

It has been suggested that the lobular pneumonia which occasionally proves fatal in some cases of removal of the tongue, is due to septic influence consequent upon the state of the mouth. The cases which end fatally occur however among elderly patients, who have become greatly reduced by the disease, and who would be likely under any circumstances to suffer from lung complications of a low type. With the view of obviating this supposed septic influence, my colleague Mr. Arthur Barker¹ has in a few cases allowed the patient to wear a tracheotomy tube for some days, and to breathe only through it, the mouth and nostrils being carefully covered with cotton-wool, and a drain for saliva being established through the floor of the mouth.

In cases of *recurrence* after removal of the tongue for epithelioma, the disease shows itself in the stump or in the submaxillary lymphatic gland, or more frequently I think in both, though I have known both to escape, and the disease to re-appear in the lymphatic gland beneath the sterno-mastoid, first on one side and then on the other. The infiltration of the glands always spreads to those beneath the sterno-mastoid, should the patient survive sufficiently long, but death usually supervenes after a few months from general asthenia and exhaustion, the sufferer being worn out by pain and, should the submaxillary lymphatic glands suppurate and open externally, as they frequently do, by the constant discharge. In cases where recovery is permanent, and the patient remains well for years, one is almost tempted to suspect a mistaken diagnosis; and it must be acknowledged that mistakes have been made by good surgeons in removing tongues, the subject of gumma, for examples of epithelioma. I am able, however, to record the survival for over twelve years of a patient from whom I removed what was believed to be a tongue affected by medullary cancer. The patient was sixty years of age, and the disease had existed six months. On looking into the mouth, there was between the tongue and the lower jaw on the left side, a ragged, ulcerated surface, occupying the floor of the mouth. This was prolonged to the side of the tongue, and with the finger a large mass could be felt in the substance of the organ, extending beyond the median line, and to about two inches from the tip. The patient complained of constant pain in the tongue, but was otherwise in good health. There was a slight enlargement of one of the submaxillary lymphatic glands. After section of the lower jaw in the median line, I removed, with the *écraseur*, the anterior half of the tongue, in September, 1868. The patient made a good but slow recovery, and called on me in 1880, nearly twelve years after the operation, perfectly well. The part removed was exhibited to the Pathological Society of London, and was submitted to the Committee on Morbid Growths. To the naked eye the tumor presented the

¹ *Lancet*, August, 1879.

appearance of medullary cancer, and was reported by the committee to consist of cells and nuclei. The conclusion drawn was as follows: "The opinion we formed is that the tumor was essentially a cell-growth invading and displacing the normal tissues, the cell-growth forming equally the more obvious cell-structure of the tumor and its fibrous portion. We may add that it seemed to us most probable that the larger forms of cells were developed out of the smaller forms, and that therefore the spongy portion of the tumor in which the larger cells were most abundant represented a later phase of development than the homogeneous portion."¹ In this case I noticed particularly a point which is not often seen, viz., the extent to which the portion of tongue left behind grows or becomes stretched. In the case in question, notwithstanding the extensive removal, the man some years after appeared to have a tongue of ordinary size, but rather more sessile in the mouth than normal.

When recurrence of cancer takes place, the case is generally beyond surgical aid, the disease usually infiltrating the tissues of the mouth and of the neck to an extent which forbids any interference. It seems to me, however, that occasionally an attempt should be made to rescue the sufferer from an early and miserable death, as in the following instance:—

A man, aged sixty-two, was sent to me in 1875, with very extensive cancerous disease of the tongue and sublingual tissues. In January, 1874, he noticed a swelling of one of the submaxillary glands, and soon after a sore beneath the tongue. The sore healed, and the gland subsided under treatment. In September, 1874, the gland began again to swell, and at last broke. At the same time he found that he had difficulty in articulating, as the tongue was fixed to the floor of the mouth, and eventually the tip of the tongue became fixed to the jaw. The latter condition was temporarily relieved by an operation at another hospital. On admission to University College Hospital, the patient was unable to protrude his tongue or move it in his mouth, the saliva constantly trickled away, and articulation was very imperfect. He complained of great pain in the occipital region, but of none in the tongue. The gums of the incisor region were swollen and ulcerated, and the teeth loose. The tongue was fixed to the back of the incisive portion of the jaw, which was softened. All the tissues beneath the tongue were indurated, but the skin was not involved.

On September 29, I removed the tongue, centre of the jaw, and all the sublingual tissues, by dividing the chin in the middle line, then sawing the jaw through on each side, and, having isolated the tongue somewhat on each side, inclosing the whole of the disease with the wire of the galvanic *écraseur*. The parts removed consisted of the middle three inches of the lower jaw, nearly the whole of the tongue, and the sublingual muscles and glands *en masse*. At the posterior end, the mass measured two and a half inches in depth, and slightly more from side to side. The tongue appeared to be healthy except at the anterior part; and on the left side, just behind the tip, was a nodule of the size of a pea. Beneath the tongue was a mass of yellowish-white, firm tissue, with a granular surface, which was continued quite up to the cut margin. This tissue, on microscopical examination, proved to be epithelioma.

The patient made a good recovery, and was alive and well six years after the operation. He recovered a surprising amount of power of deglutition, and of speech, due principally to the growth of the stump of the tongue already noticed. The occipital pain complained of by this patient is difficult of explanation, but it was entirely relieved by the operation. I have noticed it in other cases of cancer of the tongue.²

My friend and former pupil, Mr. Rushton Parker, of Liverpool, has recorded³ two cases in which he performed almost as extensive operations as in the foregoing case. In one patient, aged fifty-eight, he removed, in 1876, half the tongue, parts of the upper and lower jaws, the submaxillary glands, and a portion of the pharynx, for extensive epithelioma, the patient recovering,

¹ Pathological Society's Transactions, vol. xx.

² Lancet, vol. i. 1876.

³ Medical Times and Gazette, December 1, 1877.

and being perfectly well in 1880. In the other patient, aged fifty-four, he removed one-half of the tongue, half the soft palate, the side of the pharynx, the submaxillary glands, and part of the lower jaw, for epithelioma, but unfortunately a recurrence of the disease took place in the neck.

MALFORMATIONS AND DISEASES OF THE PALATE.

CLEFT PALATE.—Cleft palate occurs in infants otherwise well formed, or in combination with harelip, and in either case may affect the soft palate only, or both the hard and the soft palates. When harelip is present, the fissure usually extends from the lip through the alveolus and the entire palate; but there are many exceptions, a fissure of the soft palate alone frequently accompanying a single harelip. That both affections are the result of arrest of development in the early weeks of foetal life, cannot be doubted, and that they are hereditary cannot be denied. Still, cases of cleft palate occur in families not known to inherit the malformation, and in the great majority of cases it will be found that the mother has been much out of health in the early weeks of pregnancy, or that the pregnancy has followed very closely upon a previous one, or has occurred during lactation.

The experience of Professor Haughton, of Dublin, first showed, in the case of the larger carnivora, the effect of diet upon the production of cleft palate; and it is very desirable in the case of a parent the subject of the deformity herself, or having already given birth to a child with cleft palate, that in subsequent pregnancies every care should be taken to improve her health, and to administer food and medicines calculated to promote the formation of bone.

When a harelip and cleft palate are continuous, the latter deformity is sufficiently obvious; but when a cleft palate occurs alone, it may be easily overlooked for the first few hours of life, and the earliest intimation of the malformation may be given by the inability of the infant to suck, and by the fact that milk introduced into its mouth with a spoon returns through the nostrils. Under these circumstances, infants are often allowed to pine away through insufficient feeding, but with proper care this may generally be obviated.

A large-sized, India-rubber teat, or an ordinary covered spoon, such as is used for the administration of nauseous medicines, may be used to convey the milk to the gullet; but a much less troublesome and more effectual method is that adopted by Mr. Oakley Coles,¹ who attaches a flap of elastic India-rubber to the nipple of an ordinary feeding-bottle. This overlies the nipple, and is introduced into the mouth with it, and, when the infant is suckled, rises up against the cleft and enables the child to swallow. The India-rubber is undoubtedly the cleanest and most effectual flap which can be employed, but I have often directed the use of a leaf-shaped piece of kid leather with advantage, when the India-rubber could not be readily procured. Mr. Francis Mason² has employed a very thin plate of soft metal, moulded to the patient's mouth, but acknowledges that the instrument is not available in all cases. If no other plan is adopted, the mere closing of the nostrils by the nurse's finger and thumb, at each effort of deglutition, will give material assistance to successful swallowing.

The question of surgical interference in cases of cleft palate is one which must be considered as still *sub judice*. That it is possible to close the entire

¹ Deformities of the Mouth, Congenital and Acquired, with their Mechanical Treatment. London, 1881.

² On Harelip and Cleft Palate. London, 1877.

length of a cleft, extending through both hard and soft palates, at an early age, is undoubted; but it may be questioned whether in many of these cases a better result, as regards articulation, would not have been obtained by the use of some form of apparatus. It is most satisfactory to the parents of a child suffering from any congenital malformation, that the deformity should be repaired by operation as soon as possible, but grave disappointment is apt to follow when, as years go on, the power of articulation fails to improve in the ratio anticipated. The sufferer is inclined to complain that the operation has not improved his voice as much as his power of eating comfortably, and is sometimes annoyed to find that no mechanical contrivance can be subsequently worn, without undoing what was effected with so much trouble and suffering some years before.

In deciding, therefore, as to the propriety of an operation for cleft palate, it is necessary to take into account not merely the mechanical difficulty of bringing the soft tissues on each side of the median line into sufficiently close proximity to unite, but also the *length* of the palate, and the probability that it will sufficiently shut off the mouth from the nose to prevent the nasal intonation which is commonly met with, both before and after these operations. In no case of successful operation for cleft palate, I believe, is the palate sufficiently in contact with the back of the pharynx to allow water to be injected from one nostril into the other without entering the pharynx when the mouth is open, as is the case in well-formed throats. And yet many of these patients have very little nasal intonation, which is to be explained, I believe, by the hypertrophied condition of the muscles forming the pillars of the fauces, which may be seen when the patient attempts to swallow with the mouth open, acting powerfully to narrow the fauces, and thus make up for the deficient length of the palate.

Before deciding therefore as to the advisability of an operation upon the soft palate, it is well to grasp the chin of the patient and hold the mouth open so as to aid his efforts at swallowing, when if the two halves of the soft palate come in contact in nearly their whole length, while the superior constrictor and palato-pharyngeal muscles closely approximate the palate and pharynx, the case is one in which union may almost certainly be obtained, and probably a fair result as regards phonation.

In the case of the hard palate, there is an undoubted disposition for the two sides of the cleft to approach one another for some years after birth; and this is particularly seen in cases complicated with harelip, in which the successful closing of the lip tends powerfully to approximate the divided edges of the alveolus and palate. But success in closing the fissure in a hard palate depends in no small degree upon the mode in which the palate is arched. As was pointed out by Sir W. Fergusson, in cases of highly arched palates, which in section would resemble a Gothic arch, it is comparatively easy to dissect down the muco-periosteum sufficiently to make the flaps approximate; while in palates but slightly arched, and the section of which could resemble a Norman arch, it is difficult to get the flaps together, and the tension must necessarily be severe.

It is quite true that these cases of slightly arched palate give the best results as regards the voice, when the operation is successful, and that the high palates, when most successfully closed, are apt to lead to disappointment; but this might well be anticipated, since it is by no means uncommon for a person with a healthy, high palate, to speak with a nasal intonation closely resembling that of one suffering from a congenital cleft, or from perforation by disease.

The effort involuntarily made by all patients, the subjects of cleft palate, to shut off the nose from the mouth in speaking, is aided as they grow up by a

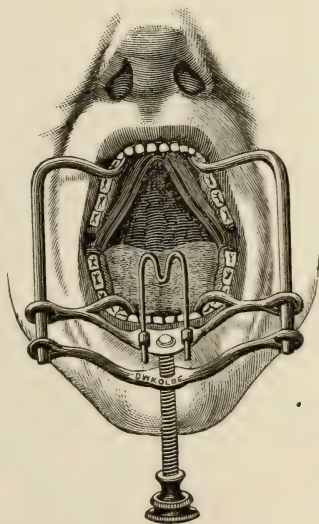
voluntary closure of the nostrils which is very remarkable. Ordinarily, in man, the nostrils are perfectly quiet in tranquil respiration, and it requires considerable effort to close them, as when plunging the face into water. A patient with cleft palate, on the contrary, may be noticed to put his *compressores narium* into strong action every time he speaks or swallows, and it is very difficult to overcome the habit when the necessity for it has passed away, through either a successful operation or the adaptation of well-fitting apparatus.

Staphyloraphy, or the operation for closure of a cleft palate, was up to the last fifteen years almost invariably postponed until the period of puberty, or later, so that the surgeon might have the patient's self-control to aid him in his troublesome and tedious operation. A few cases had no doubt been operated upon in childhood, with indifferent success, by Mason Warren and others, but to Mr. Thomas Smith, of St. Bartholomew's and the Children's Hospital, is mainly due the credit of showing that it is possible to operate in infancy under chloroform, not only without risk but with very great success. In his paper in the *Medico-Chirurgical Transactions* (1868), Mr. Smith described a gag by which the mouth of the patient can be kept sufficiently open, and which, in some form or other, is essential for the due performance of the operation, now performed by him as follows. [Fig. 1072 illustrates a convenient form of mouth-gag and tongue-depressor combined.]

The patient is placed on a table of convenient height, facing the window, and if possible a northern light. The head is supported by an air-cushion, and is firmly held by an assistant standing behind, while the arms and legs are strapped down to prevent struggling. The operator stands on the right of the patient and the chloroformist on his left. The patient being thoroughly narcotized, the gag is introduced and the mouth screwed open, the rings of the gag being held by the thumbs of the assistant supporting the patient's head. The edges of the cleft are then pared with a slender, double-edged knife, which is thrust through the margin of one side of the soft palate, held tense with forceps, and made to cut up, and then down to the end of the uvula. The margin thus separated is caught with the forceps, and the section completed up to the angle of the cleft, if possible as one sweep, or, if not, by a reapplication of the knife. The same process is repeated on the other side, and in favorable cases it is both possible and satisfactory to remove the parings of both sides of the palate in one piece.

The closure of the soft palate is then proceeded with, fine silver wire being used, with horse-hair or silk for the uvula. Mr. Smith employs a sharply-curved, tubular needle, for the wire, which is carried on a wheel in the handle of the instrument (Fig. 1073), and which can be projected when the point has traversed both sides of the palate. A twister (Fig. 1074) is employed to twist the wire up, but the last few turns are more conveniently given at the conclusion of the operation with a pair of torsion-forceps. The horse-hair is softened in warm water, and is introduced with a small curved or rectangular needle set in a handle, being passed through both sides of the palate, and caught with a "catcher" or forceps. The horse-hair is simply tied with three knots so as

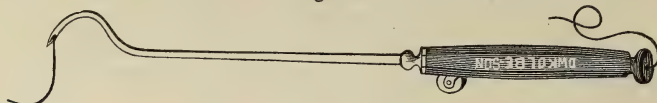
Fig. 1072.



Mearns's mouth-gag for staphyloraphy.

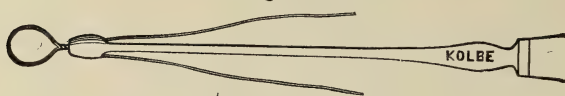
not to slip. Should there be a fissure of the hard palate, the operator proceeds to detach the muco-periosteum by a modification of Langenbeck's urano-plastic method; making a puncture near the alveolus, he introduces a palatal raspatory of small size, and brings the point out in the fissure. Then

Fig. 1073.



Tubular needle.

Fig. 1074.



Coghill's wire-twister.

meeting this with a strong aneurism-needle, he replaces the raspatory with the needle, withdrawing the former altogether, and working with the needle from the fissure towards the alveolus. In this way, aided, if necessary, by the leverage of strong, curved scissors, the muco-periosteum of the hard palate is sufficiently detached, the hemorrhage, if troublesome, being controlled from time to time by a small sponge pressed against the palate. With the curved scissors, the soft palate is then detached from the bone of the hard, one blade being passed beneath the muco-periosteum, and the other above the soft palate so as to divide the tissue transversely close to the horizontal plate of the palate bone. The muco-periosteal flaps of the hard palate are now closed by a sufficient number of fine wire sutures, and lastly an incision, as recommended by Dieffenbach, is made on each side of the soft palate, so as to thoroughly loosen it and take all tension off the stitches, which are then finally adjusted with torsion forceps.

In this operation, no formal division of the levator palati muscles, as recommended by Sir W. Fergusson, is undertaken, but it is probable that the lateral incisions in the soft palate divide to a great extent the insertions of the levators, while the detachment of the soft from the osseous hard palate must necessarily divide the insertion of the tensors of the palate.

Many operators, myself among them, have found that they have obtained good union of the soft palate without even lateral incisions; but where the tension is great these should not be omitted, and in cases of great muscular irritability of the palate, the systematic division of the levators may be undertaken with advantage. Whether the division be performed as recommended by Sir W. Fergusson, with a lancet-shaped blade set at right angles to the shaft of the knife, and introduced above the soft palate, or with a straight knife thrust through the palate as proposed by Mr. Pollock, the division should be performed after the introduction of the stitches, which both serve to render the muscles tense, and also are more readily introduced before the hemorrhage which is caused by the myotomy, and which is sometimes severe, obscures the view.

The material for, and the method of introducing, the stitches, vary in the hands of different surgeons. Sir W. Fergusson preferred purse silk, and employed the method devised by Mr. Avery for introducing it, as follows: An ordinary palate-needle, carrying the silk, was passed from before backwards through the margin of the soft palate, and the loop caught with forceps and drawn out of the fissure. This being repeated on the opposite side, one silk

was looped through the other, and drawn by this means across the fissure and through both sides of the palate. In tying the silk it is convenient to use a sliding-knot, that is, one end is simply knotted firmly upon the other, when by pulling the silk the knot is slid up to the palate and will keep its place while a second knot is made over it.

In the after-treatment of a case of cleft-palate operation, it is essential that plenty of liquid nourishment should be given in the first day or two, and be followed up by semi-solid food, so that the patient's strength may be well supported, and the process of healing accelerated. The idea that any effort at swallowing, even of the saliva, must necessarily tear open the wound, was shown by Sir Wm. Fergusson to be fallacious, and the practice of starving the patient, first decried by Sir Philip Crampton, is now universally abandoned. Talking should be forbidden for the first few days, and it is undesirable that the patient should be exposed to any chance of taking cold by exposure to draught or east wind.

The time for removing the stitches after an operation for cleft palate has been greatly modified of late years, and it has come to be thought by the most experienced operators that the longer they are left the better. In most cases, silk or horse-hair sutures should be removed in from ten days to a fortnight, but fine wire sutures may be left for weeks or even months, as long as they do not scratch the tongue.

In order to improve the voice, in cases of successful staphyloraphy in which the nasal tone persists, Mr. Francis Mason¹ has proposed to divide the united soft palate on each side by a longitudinal incision, so that the soft palate may be loosened and made more flexible. The results are, however, disappointing, as the cicatrization which necessarily ensues leaves the parts much as before.

M. Passavant, with the same object in view, proposed to make a transverse incision in the soft palate, which could then be drawn forward and reversed. A portion of the mucous membrane of the upper surface was then to be dissected off, and a corresponding portion of the mucous membrane of the pharynx, and the two raw surfaces were to be brought together with a few sutures. As Sédillot remarks, however, it is difficult to understand how the two surfaces could be brought in contact; and the experience of all surgeons goes to show that permanent separation of the posterior nares and pharynx by cicatricial tissue is certain to produce nasal intonation.

Uranoplasty.—In describing the operation usually performed by Mr. T. Smith, it will be noticed that the entire fissure in both hard and soft palates is closed by the same operation. This practice is not followed by some surgeons, who content themselves with closing the soft palate first, hoping thus to influence the approximation of the two halves of the hard palate; or, in cases too wide for closure, to employ an artificial palate. It seems to me, however, that it is very undesirable to close the soft palate when the hard palate cannot be closed, for in these severe cases the soft palate is both small and short, and the results, therefore, as regards the voice, are most unsatisfactory, even after the gap in the hard palate has been filled artificially. Again, if the patient is to be subjected to the inconvenience of wearing an artificial palate at all, he may as well be fitted with one to fill up the whole cleft, and thus improve the voice, which will be impossible if the scanty soft palate has been united.

The late Dr. Mason Warren,² of Boston, was the pioneer in closing fissures of the hard palate by dissecting down a flap of mucous membrane, and his success was such as to encourage other surgeons to imitate his practice. He

¹ *Lancet*, vol. ii. 1869.

² *American Journal of the Medical Sciences*. 1848.

worked *from* the margin of the cleft, using sharp knives bent at a right angle to detach the periosteum, which was then united with sutures. Mr. Avery was the first to follow his example in England.

In 1862, Langenbeck published his experience of operating from the alveolus *towards* the margin of the cleft, and laid especial stress upon detaching the periosteum, by means of blunt raspatories, to form part of the thickness of the flap. Having performed this operation on several occasions with good success, I can speak well of it, notwithstanding that the incision near the alveolus may, if carried too far back, give rise to troublesome hemorrhage. Two instances in which nearly fatal hemorrhage occurred from the posterior palatine artery, have been recorded by Mr. Howard Marsh,¹ in both of which the bleeding was successfully arrested by plugging the palatine canal with a wooden plug, pushed through the palate.

In 1874, Sir William Fergusson brought forward what was then believed to be a new proposal, but was afterwards shown to be a revival of a suggestion of Dieffenbach's—viz., to detach the bony edge of the hard palate with a chisel, and to push the two portions of the hard palate toward the median line. In his early cases Fergusson used silk sutures, but he subsequently found that he gained sufficient approximation by stopping the gap made on each side with lint. In this proceeding, the damage done to the parts is considerable, and necrosis, with some exfoliation, is apt to follow. Mr. Mason² has proposed to limit the action of the chisel by boring holes in the line of incision with a bradawl, before the chisel is applied; but even with this modification the operation is one of limited application, which has not found favor with many surgeons.

Although the surgeon will not undertake to supply artificial aid himself in cases of deformity of the mouth, it is essential that he should be able to advise his patient in the matter, and possibly direct the dentist or mechanic as to the method to be adopted. In Mr. James Salter's³ and Mr. Oakley Coles's⁴ works, there will be found complete historical accounts of the methods adopted by successive practitioners to obviate mechanically the deformities of the palate; but for surgical purposes, it will be sufficient to say that as regards congenital cleft palate, it is only during the last sixty years that anything like success has been attained. In 1820, M. De la Barre seems first to have employed "elastic gum" in making artificial palates; and in 1828, Mr. Snell made a palate of gold with a movable velum, which was subsequently improved by Stearn (1845), Sercombe (1857), and Parkinson (1867). All these palates acted simply as obturators—that is, were placed below the palate and overlapped the margins of the cleft, thus more or less completely shutting off the nose from the mouth. In 1864, Dr. Norman Kingsley, of New York, brought before the Odontological Society of Great Britain an artificial palate made entirely of vulcanized rubber, cast in moulds of metal taken from impressions in plaster-of-Paris. The velum of soft rubber had the great peculiarity that it fitted between the halves of the split palate, and moved with them, at the same time filling up the gap between the palate and back of the pharynx. With this palate, adapted by Mr. Coles, I have seen very remarkable results; but the method has the drawback that, if applied to patients whose growth is not complete, frequent alterations are required, in addition to the fact that the soft rubber wears out and requires renewal. A palate on a totally different principle, contrived originally by Dr. Wilhelm Swersen, of Berlin, and lately brought to my notice by Mr. Oakley Coles, appears in many cases to

¹ Clinical Society's Transactions, vol. xi.

³ Dental Pathology and Surgery. London, 1874.

⁴ Deformities of the Mouth. London, 1881.

² Lancet, Oct. 24, 1874.

afford the most satisfactory means of treating cases of wide congenital cleft of the palate. It consists entirely of hard rubber, the posterior part being much thicker than the hard palate, to which it is attached by a narrow stem; this posterior part, which is triangular in shape, is set at an angle so as to pass above the soft palate and fill up the cavity of the pharynx, the edges of the soft palate coming in contact with it in deglutition and phonation. Mr. Coles has found that the tone of the voice is improved by substituting gold in the hard palate. Having induced a highly intelligent medical student to try one of these palates, after having worn one of Kingsley's, he informs me that he has no hesitation in giving the preference to the former, whilst I am able to testify personally to the improvement of his voice.

Whatever method of treating a congenital cleft palate may be adopted, the improvement in the voice must be gained, to a great degree, by education. A patient has in the first few years of life acquired vicious habits of speaking, and particularly a guttural and nasal tone, which requires great care to overcome. It is essential that he should be taught to speak with his lips, and to throw the voice forward. With proper teaching and diligent practice, he will in time speak as distinctly as the majority of healthy persons.

ULCERATION OF THE PALATE is usually of syphilitic origin. Mucous patches with superficial ulceration, more or less circular in shape, are not infrequent in the secondary stage of syphilis, but the well-marked ragged ulcers, with a yellow base, are found either in tertiary or congenital syphilis. The mucous patches yield readily to ordinary anti-syphilitic treatment, but the tertiary ulcers are apt to perforate the soft palate and eat into the uvula, or may destroy the muco-periosteum of the hard palate, and lead to exfoliation of bone. The existence of so-called strumous or tubercular ulceration of the palate may be doubted, since in these cases a rapid cure is effected by the administration of the iodides in full doses, exactly as in cases of recognized, tertiary syphilis. The adhesions of the palate to the pharynx which are apt to follow extensive tertiary ulceration are best let alone, since any surgical interference is not likely to improve the intonation. When the soft palate is destroyed, or the hard perforated, an obturator may be worn with advantage.

NODES OF THE HARD PALATE are not infrequent in constitutional syphilis, and in the recent state are apt to be confounded with abscess. An abscess always extends from the alveolus, and usually that of the incisor teeth, which will be found to be painful and loosened; and on applying pressure to the swelling, pus exudes by the sides of the teeth. A node, on the other hand, is less rapid in formation than an abscess, and is isolated from the alveolus, the teeth being firm, although possibly tender. The distinction between the two affections is important, since the early incision, which is essential in the cure of the abscess, in order to prevent necrosis, will in all probability lead to this very result if the node be incised, whereas the latter will rapidly subside under the free administration of the iodides.

NECROSIS OF THE HARD PALATE, when it occurs, is followed by very slow exfoliation, and nothing can be done to hasten the process. The use of detergent mouth-washes to keep down the fetor, and the removal of sequestra as they form, constitute the whole treatment.

Fortunately, exposed portions of the hard palate do not always necrose, but have a singular power of recuperation, due doubtless to the abundant vascular supply to both surfaces of the palate. In order that bare bone may thus recover, it is essential, however, that it should be protected from the con-

stant contact of the tongue, and the lodgment of particles of food. For this purpose, a metallic or vulcanite plate must be fitted to the mouth, so as to cover without pressing against the affected part. This is even more important when a small exfoliation with perforation has taken place, for even then if the parts are healthy a cure may thus be effected. Any attempt to plug such an aperture must inevitably lead to its rapid enlargement, and, if persisted in, will cause absorption of the entire palatine process, as in a specimen in the museum of St. Bartholomew's Hospital, London.

TUMORS OF THE PALATE.—A case of *papillary tumor* of the hard palate has been described by Salter, which, as it recurred, was probably an example of true papilloma.

A few cases of *congenital tumor* of the palate are recorded, one of the most recent being an example of *dermoid tumor*, springing from the upper surface of the soft palate, in a child of three years. It was removed by Mr. Marrant Baker, and was exhibited at the Pathological Society of London, in April, 1881, by Dr. Hale White, who described the tumor as two inches in length, with a wide base, and consisting of epidermis, papillæ, corium, and fat, and having on one surface a plate of cartilage. In the museum of St. Bartholomew's Hospital, is a section of a boy's head with a large lobed tumor of *myxomatous* structure in the soft palate, which suffocated the patient by obstructing the larynx.

The *glandular* structure of the soft palate, which in health forms a considerable portion of its thickness, may become hypertrophied and form a tumor; and this, from its position, may give rise to great inconvenience by interfering with the voice and deglutition. A case of the kind was under my notice for some months, in the person of a married lady aged thirty-four, otherwise in good health. As the tumor slowly increased and interfered with her profession as a vocalist, I thought it right to interfere, and in July, 1879, having taken the precaution to perform tracheotomy, and to introduce Trendelenburg's tampon to obviate the entry of blood into the windpipe, I incised the tumor, and was agreeably surprised to find that I was able to turn out with the finger, from between the layers of the palate, a soft mass of gland structure, distinctly encapsuled, afterwards withdrawing the containing cyst. The patient made a good recovery, and has remained well since. *Encysted tumors*, probably of the same nature, have been met with in the hard palate.

Sarcoma of the round-celled variety affects both the hard and soft palate. I had recently under my care a child of seven, with a tumor of the right side of the soft palate, which had been punctured under the idea that it was an abscess. It closely resembled the tumor in the preceding case, externally, but upon cutting into it I found it extensively attached, and a small portion removed for examination proved it to be a round-celled sarcoma. The child survived six months. In a woman aged forty-eight, who had a tumor of the hard palate, the size of a horse-chestnut, which had been noticed from childhood but had latterly increased rapidly, I succeeded in removing the growth, which proved to be a round-celled sarcoma, and, by the application of the actual cautery to the bone from which it sprang, induced a superficial exfoliation with, I believe, a permanent cure.¹ A similar specimen, removed by Sir Wm. Fergusson, is in the museum of the Royal College of Surgeons. Dr. David Foulis,² of Glasgow, has recorded the case of a man aged thirty, from whom he successfully removed a round-celled sarcoma involving the right side of the soft palate and tonsil, through an incision carried horizontally from the angle of the mouth, with division of the angle of the lower jaw.

¹ Lancet, November 18, 1876.

² British Medical Journal, Oct. 12, 1878.

The hard palate, which resembles the gum in structure, is like it liable to *epuloid* growths of a fibrous nature, closely connected with the periosteum and bone, and therefore requiring free removal. The trephine was advantageously employed by Syme in a case of this kind, but, in the majority of instances, a superficial exfoliation produced with the cautery will give complete immunity from return, without causing subsequent deformity.

Epithelioma may invade the palate primarily, but more frequently it extends from the gums or tonsil. In the latter case its nature is readily recognized, but in primary epithelioma of the palate it may be difficult to distinguish it in the earlier stages, and the disease is often more extensive than at first sight appears. In a man lately under my care, who presented an epithelial ulcer confined apparently to the palate, which I destroyed with the actual cautery, I found extensive mischief spreading into the antrum, and recurring after free removal. When the disease begins in the alveolus, it spreads upwards into the antrum and along the palate, in the form of an out-standing growth and not in that of an ulcer. Hence the nature of the case is sometimes overlooked at first, and attention is apt to be concentrated upon the offensive discharge from the nostril, and other symptoms suggestive of suppuration in the antrum. Nothing, however, less than early and free removal of the whole disease can be of any service, and even then recurrence cannot always be prevented.

DISEASES OF THE GUMS.

HYPERTROPHY OF THE GUMS occurs as a congenital affection, and cases of it have been recorded by Gross, Salter, MacGillivray and others. In the Transactions of the Royal Medical and Chirurgical Society,¹ is a record of three children of one family who all presented hypertrophy of the gums, and who were also the subjects of *molluscum fibrosum*. All these children were of weak intellect. I brought before the Odontological Society of Great Britain, in 1878, two remarkable cases of hypertrophy of the gums, one in a child of five years, and the other in a young man of twenty-six. In the child the hypertrophy was general, involving the whole of the gums of both jaws, but in the young man it was partial, being confined to the gum and alveolus of the right side of the lower jaw, from the right wisdom tooth to the left canine. A cure was effected in both cases by removing the affected alveolus with the contained teeth, by means of powerful cutting forceps; and nothing less severe is effectual, since it has been shown by Mr. Charles Tomes that in these cases the disease dips into the socket of the teeth, and that therefore mere paring away of the redundant gum does not effect a cure.

A NÆVOID CONDITION OF THE GUM is occasionally met with as a congenital affection, and I have known it to coexist with an extensive port-wine stain of the face. In this patient, an otherwise healthy young woman, the nœvoid growth appeared to take on greater activity with each pregnancy, and I removed the vascular outgrowth on two or three occasions, applying the actual cautery freely for the arrest of hemorrhage.

A vascular, non-congenital tumor of the gum may originate from irritation of the teeth, especially in the region of the incisors. When small, these growths may be treated with caustics, but if large and causing hemorrhage, they should be removed, and the surface from which they grow should be touched with the actual cautery.

¹ Medico-Chirurgical Transactions, vol. lvi.

POLYPUS OF THE GUM, or simple hypertrophy due to irritation, is not uncommon in the neighborhood of decayed teeth, or where an accumulation of tartar has been allowed to take place. The affection, when of considerable size, may resemble epulis, but differs from it in being unconnected with the periosteum; and hence it requires much milder treatment. The removal of the tartar or the decayed teeth, and the use of an astringent wash, are sufficient in most cases; if the growth is large, it is generally pedunculated, and therefore readily snipped off with scissors, or, if sessile, it may be cut off and cauterized with Paquelin's cautery. Salter describes a true warty affection of the gums, and also a condylomatous condition occurring in constitutional syphilis.

GINGIVITIS, OR INFLAMMATION OF THE GUMS, is a common affection in infants who are cutting their teeth. The mouth is hot and tender, there being a constant dribbling of saliva, and the child's health is interfered with by the loss of rest, and by diarrhoea, and possibly convulsions, caused by the irritation of the system. Free lancing of the gums is the only trustworthy remedy, and should be had immediate recourse to in all cases of severity, although in slight cases rubbing the gums with the *syrupus croci*, or with one of the numerous but dangerously narcotic "soothing-syrups," may be sufficient.

A SPONGY CONDITION OF THE GUMS, often called scurvy, but which differs entirely from the gum of true scurvy, is common in persons who neglect the cleanliness of their teeth, or who are in feeble health. According to Salter, the disease consists essentially in vascular dilatation of the papillary and other capillaries, with a general thickening of the gum itself. The treatment consists in improving the general health, and in using the tooth-brush vigorously with some astringent mouth-wash. The spongy gum due to the administration of mercury, differs from the preceding in presenting a well-defined red line along the margin of the gum, before the sponginess comes on, combined with fetor of breath, and a metallic taste in the mouth. The blue line of plumbism is due to a formation of sulphide of lead, and the green line of copper-poisoning to the oxidation of copper in the superficial tissues of the gum.

In *true scurvy*, due to deprivation of vegetable diet, the gums are swollen and livid from submucous extravasations of blood, and they bleed on the slightest touch. In advanced cases the gums become black and sloughy, protrude between the lips, and are horribly offensive. Such cases are seldom seen except in seamen who have been improperly fed and deprived of lime-juice during a long voyage; but mild cases of scurvy, characterized by subcutaneous ecchymoses in other parts of the body, may be met with, and like the more severe ones yield promptly to the administration of fresh fruit and vegetables. Bleeding from gums apparently healthy, is a common symptom in the hemorrhagic diathesis, and may be best checked by pressure and by the administration of hæmostatics in the form of iron and the mineral acids.

TRANSPARENT HYPERTROPHY OF THE GUMS.—Under the name of *transparent hypertrophy*, Mr. Salter¹ has described a very rare affection of the gums, first noticed by the late Mr. Thomas Bell, F. R. S. "It consists in the slow and gradual hypertrophy of the extreme edge of the gum, at first like a cord, and very sharply marked from the immediately contiguous healthy-looking structure; but the most remarkable circumstance is the singular color of the hypertrophied part: it is pale pink and semi-transparent. It is very callous and insensitive, and scarcely bleeds when cut. As the disease progresses, the

¹ Dental Pathology and Surgery 1874.

hypertrophy of the gum-edge increases, but it does not alter its character or lose its sharply defined limit. The teeth, when the affection exists, become slowly dislocated and pushed into irregular positions; they ultimately become very loose; when extracted, scarcely any blood flows. When the tooth is removed, the gum heals very slowly indeed, and the edge of the wound long continues of the same pale transparent aspect."

EPULIS is a term often used to include any form of tumor involving the gum, but may be conveniently restricted to the fibrous form which alone is strictly connected with the gum and alveolus. It is a slowly growing tumor, arising most commonly between two teeth which may or may not be decayed. By pressure it tends to separate the teeth if they are healthy, or it may completely cover in the stumps of decayed teeth. As epulis is closely connected with the periosteum of the alveolus, mere cutting away of the growth is insufficient for its eradication, and nothing less than cutting away the portion of alveolus from which it springs, or inducing its exfoliation by the application of the actual cautery, can be relied on. In order to do this, it is generally necessary to sacrifice the tooth on each side of the growth, and occasionally in removing the tooth the whole growth comes away, being in these cases attached to the peri-odontal membrane, instead of to the alveolar periosteum. An epulis, on section, is found to consist of dense fibrous tissue, closely resembling the normal gum, and it frequently contains masses of bone, which may or may not be directly continuous with the alveolus. According to Cornil and Ranvier, the common epulis is an ossifying sarcoma, the bone transformation being of an imperfect description.

MYELOID TUMORS are not uncommon about the alveoli (hence "myeloid epulis"), but are only the superficial portions of deeper growths. The remarkable feature about these growths is the dark color which is often to be seen on the surface of the gum-tumor previous to, or, more frequently, after removal. A very thorough and complete removal of these growths is necessary to insure a cure, and hence they are more properly classed among tumors of the jaw, which they commonly involve.

PAPILLOMA occasionally affects the gums and requires free removal. Salter describes a case of the kind which occurred in Sir W. Fergusson's practice, and in which recurrence after removal had frequently taken place.

ULCERATION OF THE GUM occurs in children as the result of stomatitis,¹ but in the adult may be due to struma, syphilis, or epithelioma. Salter² narrates a case of *strumous ulceration* affecting the gums and palate in a youth of nineteen, of highly strumous diathesis, and thinks that the disease may be more common than is supposed. *Syphilitic ulceration* may affect the gums as well as other portions of the buccal mucous membrane, and occurs as a rule before middle age. *Epithelioma* affects the gums in patients over forty, and is often apparently connected with irritation caused by ill-fitting tooth-plates. Any ulceration in the mouth of an elderly patient which does not heal readily, should arouse a suspicion of epithelioma, and I insist upon this strongly, because, in the early stage, cases of this description are generally seen by dentists, who do not always appreciate the full gravity of the case and the necessity for prompt interference. When fully developed, the ulceration is ragged and irregular, and tends to spread from the gum to the cheek externally, or to the side of the tongue internally. The teeth in the neighborhood

¹ See p. 887.

² Op. cit.

are loosened, and possibly the submaxillary lymphatic glands may be enlarged, as they always are in the later stages of the disease.

Having treated several cases of epithelioma of the gum, I am convinced that nothing but very free removal offers the patient a chance of permanent relief. It is impossible to say how deeply in the jaw the epitheliomatous growth may have penetrated, and therefore it is better not to be content with simply cutting away the alveolus with bone-forceps, but to remove a piece of the whole thickness of the jaw, well beyond the disease. It is true that this leads to a permanent deformity, which one would gladly avoid; but to omit it is to almost court failure, with probable infiltration of the lymphatics, and a rapid termination. I have elsewhere¹ reported the case of a man, aged sixty-eight, from whom I removed the horizontal ramus of one side of the jaw, together with part of the floor of the mouth, for extensive epithelioma, who notwithstanding his age made a good recovery, and who presented himself two years afterwards in perfect health. Whereas in cases in which I have been content to remove the alveolus only, I have been often disappointed in the results. Any enlarged lymphatic glands beneath the jaw, may readily be removed at the same time, and thus an additional chance of immunity will be afforded. A remarkable example of extensive and successful removal of epithelioma of the lower jaw, was lately seen by me in a military man aged fifty-three, from whom Dr. Partridge, of Calcutta, had, in December, 1879, removed the left horizontal ramus with the submaxillary glands. Recurrence taking place at the chin, the right horizontal ramus and the glands were removed in March, 1880, by Dr. McCleod, also of Calcutta, and the patient returned to England, where I saw him in July, 1881, in perfect health; the parts were quite sound, there being one and one-half inches of space between the two halves of the jaw, and his only complaint being of a sense of tightness and want of saliva. He was alive and well in June, 1883.

DISEASES OF THE JAWS.

INFLAMMATORY DEPOSIT may take place in the *lower jaw* as a consequence of tooth irritation, and may rapidly lead to great swelling and deformity. When the tooth which has excited the inflammation is extracted, the swelling slowly subsides, but often some deformity exists for months; and it seems probable that some at least of the cases of fibroma found in the interior of the lower jaw, have originated in inflammatory deposit kept up and irritated by the presence of the fangs of carious teeth.

ALVEOLAR ABSCESS occurs in both jaws as the result of inflammation connected with the teeth, and originating in the socket. The earliest symptom is pain, with slight protrusion of the tooth, due to the inflamed condition of the membranes covering the tooth and lining the alveolus. If not relieved by judicious leeching or incision, matter forms in the socket, and either finds its way out by the side of the tooth, which is necessarily loosened, or, after causing great pain for a day or two, perforates the alveolus, and finds its way beneath the gum. This is the ordinary form of "gum-boil," which breaks spontaneously, after causing much suffering, unless previously relieved by a timely incision. The propriety of an early, free incision through the gum, down to the alveolus, is strongly to be insisted on, since necrosis and consequent exfoliation of large portions of the jaw not unfrequently follow neglect or postponement of the operation. Extraction of the tooth alone is not sufficient,

¹ Lancet, vol. ii., 1880.

where the alveolus has been perforated, and in many cases the incision will serve to preserve a useful though dead tooth for many years. The only accident which I have known to occur in connection with this operation, was the awkward one of a wound of the facial artery, from the edge of the knife being turned towards the soft tissues instead of against the alveolus.

But alveolar abscess does not always point within the mouth. The perforation of the alveolus may take place beyond the line of reflection of the buccal mucous membrane, and then the matter has to find its way to the nearest skin. In this way abscesses, with their resulting fistulæ, may be seen on any part of the face or neck; and occasionally grave errors of diagnosis are made from non-recognition of the fact that alveolar abscesses may burrow for long distances. I have known one instance of fatal suppuration between the muscles of the neck, leading eventually to suffocation, due entirely to mischief about a molar tooth in a patient whose health was undermined by drink; and it is common to see cases of fistulous opening, with serious scarring of the face and neck, due solely to the presence of a decayed tooth. In the case of the upper jaw, abscess connected with the incisor teeth not unfrequently finds its way backwards along the hard palate, and occasionally, but more rarely, into the nostril, being thus liable to be mistaken for discharge from the nose itself, or from the antrum.

CHRONIC ABSCESSSES have been met with in the substance of the lower jaw, depending no doubt upon osteitis, and presumably connected originally with tooth mischief. Since the swelling is the only evidence of the abscess, for it must be very rare for the bone to be sufficiently thinned to yield the crackling feel which is characteristic of contained fluid, it is not surprising that eminent surgeons should have removed large portions of the jaw in error, mistaking the tumor for a solid growth. Hence the rule, which should be invariably followed, to perforate tumors of the lower jaw before cutting the bone, since both abscesses and cysts closely simulate solid growths. In the case of a chronic abscess, the perforation alone, with efficient drainage, would be sufficient treatment.

SUPPURATION OR EMPYEMA OF THE ANTRUM is another form of chronic abscess, but with the peculiarity that the pus is seldom so completely shut in as to produce distension. In the great majority of cases, the matter constantly escapes by the anterior or posterior nares, and it is this discharge which first attracts the patient's attention. When escaping from the anterior nares upon the handkerchief, the discharge is apt to be attributed erroneously to ozæna, but the absence of the characteristic crusts and fetor sufficiently mark the distinction. In ozæna, the patient, as a rule, has lost the sense of smell, and is unconscious of his offensiveness; whereas, in cases of pus in the antrum, the patient is conscious of an occasional unpleasant odor, but is not disagreeable to his neighbors, though the discharge when blown on the handkerchief may be offensive. Often a patient suffering from pus in the antrum complains only of a disagreeable taste in the throat and mouth, on awaking in the morning, particularly if he sleep habitually on the side opposite to that of the affected antrum, the purulent fluid then slowly flowing backwards into the pharynx and being partially swallowed, with great detriment to the digestion.

In the exceptional cases where the opening into the nose is closed, the pus tends to accumulate and produce distension of the antrum, with absorption of the bony walls, by which the characteristic crackling is produced. It may be doubted, however, whether some at least of these cases are not instances of cyst of the wall of the antrum, the contents of which have become purulent.

In cases of distension the pain is severe, and of a neuralgic and intermittent character; but in the ordinary form of the disease, there is little more than an occasional sense of uneasiness and weight about the jaws, so indistinct as often to be no guide to the side on which the mischief exists.

In the great majority of cases, empyema of the antrum depends upon inflammation of the lining membrane of the cavity, caused by the fangs of decayed teeth, which, if not actually perforating the membrane, are in close proximity to it, either from unusual depth of the sockets or from absorption of the intervening, thin portion of bone. It is possible, however, that the mischief may be set up by extension of catarrhal inflammation from the nose, by blows on the face, or even by the pressure during birth, in the case of an infant. A careful examination of the teeth will, in most cases, show which of them is in fault, and, though the first and second molars are those of which the fangs most frequently cause mischief of this kind, it must be remembered that the canine frequently, and the incisors more rarely, are connected with an unusually extensive antrum. The extraction of a decayed tooth or fang may be followed by an immediate discharge of pus, in which case an enlargement of the opening will probably be required; but frequently the tooth which has set up the mischief has been long extracted, and it then becomes necessary to perforate the antrum above the alveolus. For this purpose a drill, a gimlet, or an ordinary trocar of medium size may be employed. If the bone happens to be thin, any instrument passes through readily, and the operator is aware that he has entered a cavity, and may, if he does not hold the perforator judiciously short, transfix it and come in contact with the orbital plate. But in many cases the bone is extremely dense, and the instrument is gripped so tightly that it is impossible, until it is withdrawn, to be sure that the cavity of the antrum has been reached.

Whether the perforation be made through or above the alveolus, an ordinary Eustachian catheter of silver or vulcanite will be found very convenient for washing out the antrum, and a simple India-rubber ear-syringe with a bullet-joint will be sufficiently powerful for the purpose. Ordinarily, fluid injected through the perforation flows readily from the nose, bringing away a quantity of more or less inspissated pus of offensive character; but occasionally the cavity of the abscess does not communicate with the nose, and the fluid must then be allowed to flow back by the perforation.

The after-treatment of these cases consists in maintaining the aperture patent, which is often difficult, until all purulent secretion has ceased; in washing out the cavity at least thrice daily with warm Condyl's fluid and water; and in throwing in a small quantity of stimulating lotion, such as two grains of sulphate of zinc in a fluidounce of rose-water. When the opening is above the alveolus, there is little danger of particles of food entering the cavity, but when the opening is through the alveolus, food will readily penetrate, unless an artificial denture be applied so as to cover the opening during mastication. When a dental plate is employed, a silver tube should be fitted to the perforation so as to maintain its calibre, and thus the occasional introduction of a trocar, which would otherwise be necessary, may be dispensed with. Still, it must be allowed that the cure of empyema of the antrum is often very tedious, and that many months may elapse before a patient can dispense with daily washing out of the cavity.

Since, as has already been said, distension of the antrum with facial deformity occurs only when the accumulating matter does not discharge into the nostril, it is easy to mistake a case of this kind for a solid tumor of the upper jaw, should the amount of distension not be sufficient to produce much thinning and crackling of the bone. Again, it appears possible that the fluid portion of the matter contained in the antrum may drain away, leaving be-

hind it a solid mass of inspissated pus and cholesterine, which, as in a case of my own, may, by its presence, induce partial absorption of the floor of the antrum, with a protrusion of the palate and all the symptoms of maxillary tumor. In order then to avoid an error which has overtaken very excellent surgeons, it is advisable, in all cases of tumor of the upper jaw in which the nature of the swelling is not obvious, to perforate the antrum beneath the cheek, before incising the skin of the face and taking the necessary steps for removal of the jaw.

The *secondary effects produced by distension of the antrum* are sometimes serious. Thus, protrusion of the eyeball from elevation of the floor of the orbit is not infrequent, and cases of permanent amaurosis have been recorded by Salter and Gaine, while occasionally death has been known to follow suppuration within the antrum.

PERIOSTITIS, both acute and chronic, affects the jaws, but the former is so prone to run into suppuration with consequent necrosis, that it is only in the early stages that it can be recognized. The more chronic form is commonly connected with syphilis, and leads to the formation of nodes about the palate, and to enlargement of portions of the lower jaw. In these latter cases, the administration of the iodides in full doses gives most satisfactory results. Many cases of persistent facial neuralgia which are unrelieved by quinine, etc., yield to the administration of iodide of potassium, and may be concluded to depend upon chronic periostitis or osteitis, with probably pressure upon the dental nerves.

NECROSIS affects the lower much more frequently than the upper jaw, probably in consequence of its being less abundantly supplied with blood. Beginning as periostitis from tooth irritation, injury, or the action of some specific poison, the general symptoms are pain, with pyrexia, and the part affected will be found to be swollen, injected, and hot, the teeth being raised from their sockets, and unable to bear the slightest pressure. If relieved by timely depletion by leeches or, better, a free incision, and the assiduous use of hot gargles and poultices, the symptoms may subside without further mischief; but usually matter has already formed beneath the periosteum before the patient is seen, and then, although promptly evacuated, necrosis is very apt to follow. Fortunately, necrosis sometimes affects the outer plate of the alveolus only, so that the teeth are supported by the inner plate and can be kept *in situ*; but when the entire socket is involved, the teeth are rendered loose and useless, and are better away, since they only plug the openings through which the discharge would find its way out. It is very undesirable to attempt removal of sequestra until they are completely loosened, since by doing so damage may be inflicted on the surrounding parts, and the process of repair be interfered with; and this is especially the case with children in whom the second teeth are still undeveloped. It is impossible to lay down any rules for the period of separation, which must depend upon the extent and position of the sequestrum, and the strength of the patient; but ordinarily, from six weeks to three months must elapse before large sequestra can be safely extracted.

By *exanthematous necrosis* (Salter), is meant the necrosis occurring in young children, for the most part after attacks of the specific fevers, especially scarlet fever and smallpox. Necrosis of portions of the alveolus of either jaw, and usually on both sides symmetrically, or even of the whole thickness of the lower jaw, is fully recognized now as one of the sequelæ of these disorders; and doubtless many of the cases which were attributed to the administration of calomel, in former days, were really due solely to the action of

the specific poison. The course and treatment of these cases differ in no respect from those of ordinary necrosis.

The action of the fumes of *phosphorus* in producing necrosis of the jaws in persons employed in lucifer-match making, has now been recognized for upwards of forty years, Lorinser being the earliest writer upon the subject in Germany. The work of Von Bibra and Geist, of Erlangen (1847), and the Report to the Privy Council, by Dr. Bristowe (1863), give the best accounts of the disease, which is now becoming rare, owing to the precautions taken in the manufacture of lucifers.

It was found that, as long as workers among phosphorus had perfectly sound teeth, their health remained unaffected; but that as soon as the teeth became carious, or were from any cause extracted, the fumes of phosphorus found their way to the periosteum of the jaws, and excited periostitis with rapid necrosis. The symptoms were severe, the swelling of the jaws and tissues of the face being extreme, and the discharge of purulent fluid from the mouth being constant and in large quantities. The general health became secondarily affected, the patient being worn out with pain and inability to take solid food, and in very severe cases being liable to gangrene of the gums and cheeks. All these discomforts have been put an end to by insisting upon cleanliness in the use of the phosphorus, by the careful examination of the mouths of the workers, but most especially by the employment of the amorphous phosphorus in the manufacture of lucifer-matches.

The remarkable point about phosphorus necrosis is the peculiar deposit of pumice-like bone which takes place upon the sequestra. This is doubtless derived from the periosteum, although so closely adherent to the sequestrum as to be invariably brought away with it; and though resembling true bone in some particulars, it is of a decidedly lower development. A form of bone closely resembling this pumice-like deposit has, however, been noticed in cases in which no phosphorus was involved, and it would appear that in some instances, possibly of rheumatic origin, the deposit of new bone partakes of this character. Whenever it does, it can in no way tend to the repair of the necrosis, for the deposit is always firmly adherent to the sequestrum, and must be removed with it.

Besides phosphorus necrosis, *mercurial necrosis* was once common, not only as a consequence of the excessive administration of mercury for antisypilitic purposes, but as a result of the destructive pytalism produced by the fumes of liquid mercury, as formerly employed in the manufacture of looking-glasses. When glass plates were converted into mirrors by sliding and compressing them on to sheets of tinfoil covered with pure quicksilver, the men employed were liable to have their teeth drop out, and frequently lost portions of their jaws, their lives being notoriously shortened. Since the introduction of a chemical process by which the mercury is deposited on the glass, these cases of induced necrosis have become almost unknown.

In ordinary cases of necrosis of the upper jaw, no reproduction of bone takes place, the gap left in adults being permanent, though in children, the subjects of exanthematous necrosis, the granulation-tissue is slowly converted into fibrous tissue, which does not, as a rule, ossify. In the lower jaw, abundant new bone is produced by the periosteum, and, for a time at least, most extensive losses are repaired. The museum of the Bellevue Hospital, New York, contains a remarkable illustration of this in a large phosphorus sequestrum, extracted by the late Dr. J. R. Wood from a girl who survived three years, and in whom reproduction of a semicircle of new bone, about five-eighths of an inch broad, with all the epiphyses, took place (Erichsen). It is certain, however, that, in the course of years, a great, if not complete, reabsorption of the new bone thus formed takes place, the patient being left ulti-

mately with very little, if any, support for artificial teeth. Salter has suggested that the early application of artificial teeth would tend by use to strengthen and maintain the permanence of the new bone; but there are no facts to support this view.

HYPEROSTOSIS OF JAWS.—Under the name *hyperostosis*, may be conveniently grouped together a number of cases in which general enlargement of the maxillary bones occurs, without any distinct tumor which could be properly placed among the osteomata. Enlargement of the angles of the lower jaw, quite unconnected with the development of the teeth, and giving a peculiarly broad appearance to the face, occurs in otherwise healthy subjects of about twenty, and these enlargements appear to remain stationary. In true hyperostosis, however, there are large bosses of bone, often symmetrical, thrown out by the bones of the face and cranium, which slowly but steadily increase in size, producing hideous deformity, and ultimately causing the death of the patient. Howship, Cooper, and Bickersteth have recorded remarkable instances of this affection, which appears to be unconnected with syphilis, and to be unaffected by medicines. Cases in which the disease is unilateral, may fairly be submitted to operative proceeding, and I have twice relieved patients from considerable deformity by sawing or gouging away a portion of the projecting bone without any external incision. In one case, that of a lady aged thirty-nine, the enlargement of the right upper jaw was attributed to a blow on the cheek; in the other, that of a man aged forty-six, the enlargement in the same situation came on apparently without cause. Sir James Paget has recorded¹ some cases of *osteitis deformans*, affecting many of the bones of the body, including the skull, which closely resembled in some particulars the cases recorded by other surgeons as hyperostosis; but in these, as also in cases recorded by Dr. Cayley and Dr. Goodhart,² cancer of some sort was present in addition. This would appear to place these cases of general osteitis deformans in a different category from those in which the disease is confined to the bones of the skull or face, and in which, as far as is known, no cancer has been found.

ODONTOMA, or tooth-tumor, is the name given by Broca to the group of cases in which the tumor consists of tooth-elements more or less hypertrophied. The majority of these are outgrowths from the pulp of well-formed teeth, or at least have their connection with the teeth well marked, and may therefore be more properly considered in the pages devoted to dental surgery. There is one form of odontoma, however, which is strictly surgical, since it is apt to give rise to serious mistakes in the diagnosis and treatment of one form of tumor of the jaw. This depends upon some modification of the germs of one or more of the molar teeth of the lower jaw, before the development of the cap of dentine, leading to the formation of an irregular mass of dental tissues in no way resembling a tooth in shape. These cases are very rare, and occur only in the lower jaw. The symptoms are those of a dense tumor expanding the bone, in which there is no pain, unless the mass should interfere with the development of the wisdom-tooth, or be mistaken for a misplaced tooth or a sequestrum, when acute inflammation may be excited in the jaw itself by ineffectual attempts at removal. Very eminent surgeons have been misled by these cases, and have unnecessarily sacrificed portions of the lower jaw, when, as experience has shown, enucleation of the growth could invariably have been undertaken with success. I have recently had under my care a case of this kind, in which persistent efforts to remove what was supposed to be an im-

¹ Medico-Chirurgical Transactions, vol. lx.

² Pathological Society's Transactions, vol. xxix.

packed tooth had given rise to so much inflammation about the jaw and gums, that, when I was first consulted, I believed the patient to be suffering from a rapidly growing tumor of the interior of the jaw, and recommended removal of a portion of the bone. Fortunately, on the subsidence of the inflammation the case more resembled one of necrosis, and, on attempting to search for and remove a sequestrum, I was enabled to enucleate an odontoma measuring one and one-half inches by one and one-quarter, and weighing three hundred and fifteen grains.¹ The tumor consisted of dental tissues irregularly arranged, and represented one or two molar teeth.

Displacement of otherwise healthy and well-formed teeth may give rise to enlargement of either jaw, and even supernumerary teeth have been known to form distinct tumors connected with the maxillary bones. Such cases must necessarily be very difficult of diagnosis, and are best treated by exploration before any serious mutilation is undertaken.

CYSTS OF THE JAWS.—The developments of *cysts* in connection with uncut teeth is a subject of great practical importance for the surgeon, since mistakes in the diagnosis and treatment of these cases are far from rare. *Dentigerous cysts* may occur in either jaw, a tumor being gradually formed, the growth of which is slow and for the most part painless. A careful examination of the neighboring teeth will be the best guide to a correct diagnosis, for, if a tooth be absent, or, as sometimes happens, if a temporary tooth occupy the position of a permanent one, the tumor in all probability is a dentigerous cyst, and no mutilating operation should be undertaken without first opening up the tumor to discover its nature.

Dentigerous cysts arise in connection with teeth which from some cause have remained within the jaw, and have undergone a certain amount of irritation. They are most commonly connected with the permanent teeth, though I have met with a cyst in a boy of four, in whom a temporary canine tooth was wanting, and on cutting into the cyst I extracted seven small, irregular nodules of dentine and enamel. Frequently the tooth in fault is inverted, but often there is nothing to explain the formation of the cyst, which is apparently due to the increase in quantity of the small amount of fluid ordinarily found in the tooth-sac after the completion of the development of the enamel. The cyst-wall is usually too dense to give rise to the crackling so characteristic of the presence of fluid within, and is lined by a thick, vascular membrane. Usually the tooth projects through this membrane, but I have met with a case in which a large cyst of the lower jaw was carefully searched in vain for a tooth, which however made its appearance some weeks after, when the membrane had been to a great extent destroyed by suppuration.

Dentigerous cysts have been mistaken for solid growths on many occasions, one of the most remarkable specimens of the kind being one side of the lower jaw, removed in error from a girl of thirteen by the late Mr. Fearn, and now in the Museum of the Royal College of Surgeons of England. Here the two plates of the lower jaw are expanded from the angle on the left to beyond the symphysis on the right side, forming a bony cyst, the cavity of which is lined with a thick, vascular membrane through which a well-formed, permanent canine tooth projects.

The treatment of these cases of dentigerous cyst is sufficiently simple when once a diagnosis has been made by an exploratory puncture. The removal of a portion of the cyst-wall, so as to allow of a search for and the removal of the hidden tooth, is all that is necessary, the cyst shrinking down as soon as a free vent for the contained fluid is secured. Occasionally the

contents of these cysts have suppurated before being opened, and in all cases care should be taken to use antiseptic lotions, and to insure cleanliness by syringing. Cysts in connection with fully developed teeth undoubtedly occur, although possibly some of the so-called cysts are nothing more than abscess-sacs, which follow the fangs to which they are attached when these are extracted. The only post-mortem examination of such a case is one recorded by Fischer, of Ulm, who, after removing the facial wall of the antrum, found a cyst connected with the apex of the last molar tooth, which filled the whole cavity.

But cysts of the upper jaw are by no means uncommon in which no connection with the teeth can be made out, and which certainly do not fill or in any way occupy the antrum. In fact, it may be doubted whether the old term *hydrops antri* is not altogether a misnomer, the cases which have hitherto been grouped together under that name being either cysts of the wall of the antrum, or cysts altogether outside the antrum, which push in its wall as they develop. The history of these cases is one of gradual, painless dilatation of some part of the upper jaw, usually close above the alveolus, the bony wall becoming so thin as to crackle like parchment, or eventually becoming simply membranous, in which case a characteristic, bluish appearance is seen on lifting the lip, and fluctuation can be readily perceived. On incising such a cyst, a quantity of dark-colored fluid of varying consistency escapes, and the finger passes into a smooth cavity not perforated by the fangs of teeth, and quite outside the antrum. By cutting away a portion of the cyst-wall, so as to insure free drainage, the cure of the cyst is gradually brought about, but very slowly. The same form of cyst occurs, but less frequently, I think, in the lower jaw.

In the earlier stage of the complaint, when the jaw is distended, but when absorption is not so far advanced as to make the nature of the case clear, a puncture with a trocar will probably evacuate cystic fluid, often containing cholesterine, and differing entirely from the mucous secretion of the lining membrane of the antrum. A remarkable specimen in the King's College Museum, figured in Fergusson's Practical Surgery, shows complete absorption of the front wall of the antrum, with great distension of the cavity, which does not communicate with the nose; but it is impossible to tell whether this was originally a case of empyema, or one of so-called *hydrops antri*.

Adams, Giraldés, and Luschka have shown that both single and multiple cysts develop occasionally from the wall of the antrum and project into the cavity, and that polypoid growths form in the same situation. A recent case recorded by Sir James Paget,¹ supplies a symptom of such polypoid growths hitherto unnoticed, viz., the constant flow, from the nostril of the affected side, of clear watery fluid in considerable quantity. The patient, a lady, aged forty-nine, suffered for nearly two years from this inconvenience, and was then relieved, and ultimately cured, by the use of sulphate of zinc, locally and internally, as recommended by Brodie in a similar case. The patient dying from causes unconnected with the antrum, its "floor was found to be covered with two broad-based, convex, polypoid growths, deep, clear, yellow, with the fluid infiltrated in their tender tissue. They looked like very thin-walled cysts, but were formed of very fine membranous or filamentous tissue infiltrated with serum."

Cysts occur in the lower as in the upper jaw, and may be single or multiple. These cysts probably originate in the cancelli of the bone, and are in many cases due to the irritation caused by neighboring teeth; a cancellus, being filled with fluid, expands, and produces gradual absorption and

¹ Clinical Society's Transactions. 1879.

obliteration of neighboring cancelli, until a cyst of considerable size is produced. One of the largest known is in the Museum of St. George's Hospital; it is figured in Holmes's System of Surgery. It extends from the symphysis to the condyle on the right side, and had existed for eighteen years. The multilocular cysts of the lower jaw appear to be more closely connected with the teeth than the single cysts, since in many cases the extraction of teeth or stumps gives exit to a quantity of glairy discharge. Distension and absorption of the alveoli go on as the cysts increase in size, so that the walls at length become membranous, and the macerated bone shows great gaps in its outline. One remarkable clinical feature in these cases is the length of time over which they extend without materially affecting the health of the patient, except by their size and the consequent inconvenience produced. I have recently put on record¹ the history of a cystic tumor of the lower jaw, extending over thirty years, the patient having had a portion of the right side of his jaw removed by Sir Wm. Fergusson in 1847, and having remained in good health for fifteen years. He then noticed the formation of a cyst in the incisor region, which was tapped from time to time by Sir Wm. Fergusson. The patient came under my care in 1877, when I found cystic disease of the symphysis and left side of the body of the jaw, extending up to the molar teeth. I then extracted all the remaining teeth and opened up the cysts freely, crushing in the walls and removing some solid material with the gouge. Considerable consolidation followed this proceeding, but a year afterwards a fresh development of cysts had taken place, and required a repetition of the operation, which was on this occasion followed by such good results that early in 1879 the jaw was completely consolidated, and the patient able to wear artificial teeth. Late in the same year, a rapidly growing, round-celled sarcoma developed in the jaw, and was removed, but similar tumors developed in the humerus and pelvis, and the patient gradually sank in 1880.

The liability of multilocular cysts of the lower jaw to develop eventually solid tumors of an epithelial type, has been recently illustrated in my own practice in another case; and also in a case of so-called cystic sarcoma, I have seen, eleven years after, a recurrence in the skin of an epithelial cancer. These facts have led me to accept the views founded upon a microscopical examination, by Mr. Frederick Eve, of tumors removed by myself and others, in the Museum of the Royal College of Surgeons, which views are given at length in a lecture delivered at the College in 1881.² Mr. Eve maintains that cases of multilocular cyst and of cystic sarcoma should be grouped together as examples of epithelioma; and if that be so, there can be no question that complete removal of the affected portion of jaw should be promptly undertaken, if any solid growth is found in connection with the cysts.

Mason Warren and Butcher have shown that by evacuating the contents of the cysts from within the mouth, and crushing in the thin walls with the fingers, a great amount of consolidation can be brought about, and, if the thick lower border of the jaw be unaffected, as it usually is, a very firm basis of support for artificial teeth may thus be obtained. The operation may bear repetition more than once in the early stage of the cystic disease, but is certainly unsafe as soon as the development of an epithelial tumor begins to show itself, when more radical measures must be adopted.

¹ British Medical Journal, May 22, 1880.

² Ibid., January, 1882.

TUMORS OF THE JAWS.

The progress of pathological investigation has, of late years, considerably modified the views held by surgeons as to the nature of many of the tumors found in both the upper and lower jaws. Modern methods of investigation have thrown doubt upon those formerly employed, and hence but little confidence can be placed in many of the earlier-recorded microscopic appearances of maxillary tumors. Fairly reported clinical histories must always be of value, but in the light of modern pathology it is impossible in many cases to reconcile the clinical history with the pathological interpretation. In the following pages, an attempt will be made to classify tumors of the jaws in accordance with modern histology; and for assistance in this endeavor I am indebted to Mr. Rushton Parker, of Liverpool, and to Mr. Eve, Curator of the Museum of the Royal College of Surgeons of England.

Among *non-malignant tumors*, or tumors composed of one of the modifications of fully-developed connective tissue (Erichsen), we may recognize fibroma, enchondroma, and osteoma.

FIBROMA.—This is found in the upper and lower jaws in the form of the hard fibrous and the softer fibro-cellular tumor. According to Broca, both the fibrous and fibro-cellular tumor may be of dental origin, forming one variety of odontoma, which is found in young persons only, and which has the peculiarity of being encysted and therefore easily removed. I have only met with one case which seemed to support this view, in the person of a young lady who had a tumor of the upper jaw, evidently due to expansion of the antrum, the walls of which crackled under pressure. Believing the swelling to be due to fluid, I punctured it, giving exit to a small quantity of liquid, and discovered a tumor within. On laying open the antrum, I was able to enucleate with the finger a tumor which had very slight attachments, presenting all the appearances of a fibrous tumor, but microscopically found to be very rich in cell elements and therefore likely to recur. Nevertheless, the patient is now in perfect health ten years after the operation.

Fibroma of the jaws closely resembles fibroma in other parts of the body, and especially the uterus. It is dense in structure and frequently lobulated, and on section shows interlacing bundles of fibres. Two varieties of origin are found: the periosteal, springing generally from the alveolus, and indistinguishable except by its size from epulis; and the endosteal, which springs from the interior of the bone, and in the upper jaw generally makes its way into the antrum and nasal cavities, or, in the lower jaw, expands the inner and outer plates of compact bone. Fibroma produces absorption by pressure, and may thus destroy a great part of the skull; it stretches the skin of the face, and may by tension produce ulceration, and thus cause an aperture, but it never involves the skin, which is always loose and movable over the tumor. The enormous size to which fibromata may grow without destroying the patient's life, is well seen in some of Liston's and Fergusson's cases, but such tumors are rarely met with nowadays. The disease never gives rise to secondary deposits, and if freely removed, so that all prolongations with the Haversian canals of the neighboring bone are got rid of, does not recur. Fibroma of the jaw may undergo calcareous transformation, as in the uterus, and occasionally the calcareous matter may become necrosed and cause suppuration. Suppuration is also found occasionally in connection with simple fibroma, but only when it has been punctured for diagnostic purposes, or otherwise irritated.

Fibroma appears to owe its origin in many cases to the irritation of decayed teeth, which may sometimes be found imbedded in the tumor, or displaced by it. No treatment less radical than the removal of the portion of bone from the periosteum of which the tumor springs, can be of avail in the periosteal variety of fibroma, but in the form in which the bone, and particularly the lower jaw, is expanded by a slow-growing tumor within it, less heroic measures may be successful. I have already referred to a case in which I removed a fibroma from within the antrum by enucleation, with complete success, and numerous museum specimens serve to show that the lower jaw is often expanded by fibrous tumors which are amenable to this treatment. Sir James Paget¹ has strongly recommended the adoption of the practice of enucleating non-malignant tumors of bone, in all parts of the body, and it is one decidedly to be followed in suitable cases.

ENCHONDROMA is of less frequent occurrence in the jaws than fibroma, and like it may be either periosteal or endosteal. The tumor appears, ordinarily, early in life, springing from the surface of either jaw, or from within the antrum or the interior of the lower jaw, and grows steadily, and more rapidly than a fibroma. It is more tuberous and harder than a fibroma, and in the case of the upper jaw is apt to send processes into the fissures and cavities of the skull, thus giving rise to great deformity by involving the nose and orbit. Many remarkable specimens of this kind are to be found in museums, the patient in some cases having been suffocated by the growth involving the mouth and pharynx. And yet, in these cases, it will be seen that the tumor does not invade the surrounding parts except by its pressure, and could have been enucleated. Enchondroma has undoubtedly a greater tendency to recur locally than has fibroma, and it is essential therefore in its treatment that free removal should be practised. Mr. George Lawson² has recorded a case of enchondroma of the lower jaw upon which Sir W. Fergusson operated six times, recurrence taking place on each occasion, and eventually leading to the formation of a large mass weighing eighteen ounces, which Mr. Lawson successfully removed. I have also recorded³ a remarkable instance of repeated recurrences of a cartilaginous tumor, extending over five and twenty years; the patient died of erysipelas, and no secondary deposits were found in the internal organs. Cases of deposit in the lungs, which have been from time to time recorded after the removal of enchondromata, have been doubtless examples of "chondro-sarcoma," an affection which will be considered hereafter, and which has but recently been differentiated from simple enchondroma.

Enchondroma of the jaws may have fibrous tissue mixed with it, or may in great part be converted into bone; and no doubt many of the remarkable osseous tumors of the jaws to be found in museums, were originally cartilaginous in their nature.

OSTEOMA is found in the jaws as a cancellous or as an ivory tumor. The simplest form is the condensed hypertrophy due to the presence of a misplaced tooth, and the fact that numerous serious operations have been performed in these cases, should make the surgeon especially careful as to his diagnosis. The cancellous osteoma has a covering of compact bone of varying thickness, but sometimes so thin as to crackle under the finger. It grows slowly to a very large size, as may be seen in a remarkable specimen in the Musée

¹ Medico-Chirurgical Transactions, vol. liv.

² Lancet, June 8, 1878.

³ Injuries and Diseases of the Jaws, p. 244.

Dupuytren, at Paris, but when removed by section of the healthy bone beyond, shows no tendency to reproduction.

The ivory osteoma I have met with both as an outgrowth from the lower jaw of a healthy woman, and as a tumor of the upper jaw of which the ivory was but a portion, the rest being composed of dense cancellous bone. Some very remarkable cases of osteoma which are on record, are doubtless examples of ossified enchondroma. In these cases the tumor has a tendency to become loosened from its attachment to the surrounding parts, and either to drop away, as in Mr. Hilton's case, or to be readily removed, as in Dr. Duka's.

In the treatment of these tumors, an exploratory puncture, or trephining, may enable the tooth which is the cause of the malady to be extracted, and hence this should never be neglected except in the case of the ivory growth. This again may be sawed off, showing no tendency to recur, or it may be extracted from the cavity of the antrum, or from the interior of the lower jaw. As a last resource the upper jaw, or a portion of the lower, may be removed with the tumor, but extensive mutilations should not be undertaken for benign and slowly increasing tumors if they can be avoided.

PULSATING TUMORS of the upper jaw have been occasionally met with, and are mostly examples of vascular sarcoma. In the Museum of University College, London, is a specimen of true erectile tumor of the upper jaw and pterygo-maxillary fossa, removed in 1841 by Mr. Liston from a man aged twenty-one, who had suffered from frequent hemorrhages from the growth. The tumor is everywhere bounded by a dense layer of fibrous tissue, but "on section the divided surface has a uniformly open, cavernous structure, like that of the corpus cavernosum penis, the meshes of which are nowhere occupied by a solid substance, and probably allowed of the circulation of blood through them."

CYSTIC SARCOMA.—Under the old term "cystic sarcoma," were included probably more than one variety of solid growth in which cysts were developed. The presence of cysts was held to mark the non-malignant character of the disease, and the clinical histories of the recorded cases appeared to support this view. The naked-eye appearance of the solid growth was that of a fibrous or fibro-cellular tumor, and this was considered to be its nature until within a few years. In 1871, Mr. Wagstaffe¹ described a tumor of this kind as consisting of a peculiar arrangement of what appeared to be acini or cylinders of closely-packed cells, supported by a fibro-nucleated matrix. In the same year, I removed a large cystic sarcoma involving the right side of the lower jaw, which presented many of the appearances described by Mr. Wagstaffe, and led Mr. Beck to describe the tumor, in the Catalogue of the Museum of University College, as a peculiar, "gland-like tumor of bone," affecting only the lower jaw. One-half of this tumor having been presented to the Royal College of Surgeons, has recently undergone fresh examination by Mr. Eve, the curator, who from his investigations upon it and other similar tumors, has come to the conclusion that they originate in an ingrowth from the epithelium of the gum, and should be classed among the epitheliomata. He would attribute the development of cysts to degeneration of the epithelial cells, and the apparent immunity from recurrence to the fact that these tumors are more or less completely encased in a shell of bone. I was hardly prepared to accept this view in its clinical aspects, when, early in 1882, the patient from whom, in 1871, I had removed nearly the whole of the right side of the lower jaw for "cystic sarcoma," reappeared with a large ulcer of

¹ Pathological Transactions, vol. xxii.

the cheek, presenting all the appearance of epithelioma. Upon removing this, by cutting freely around it, I found it connected strongly and deeply with the coronoid process and condyle of the lower jaw, which I had not removed at my former operation, thinking it unnecessary to do more than go well beyond the disease. This case then goes far to confirm the view that "cystic sarcoma" is really epitheliomatous in its origin, and that its removal should be as free as in cases of more fully recognized epithelioma.

But a much wider question is thus opened up, viz., whether, as Mr. Eve believes, cases of multilocular cyst in the lower jaw, accompanied, as they usually are, by more or less solid growth, are also examples of epithelioma. In his Erasmus Wilson Lectures for 1882, Mr. Eve has fully discussed this question, and certainly the fact recorded by myself on a preceding page, of a solid tumor forming after a thirty years' existence of cystic disease, would tend to show that the malady in question is not as harmless in its course as has hitherto been supposed. Still, the clinical history of these cases, and also of the cases of ordinary "cystic sarcoma," differs so completely from that of ordinary epithelioma as to rapidity of progress and recurrence after removal, that further observation is necessary before a decided opinion can be arrived at on the whole question.

SARCOMATA.—Under the term sarcoma, modern pathologists include all tumors composed of tissue which is either embryonic, or which is undergoing one of the primary modifications seen in the development of adult connective tissue (Erichsen).

In connection with the jaws, various forms of sarcoma are found, many of which have hitherto been known by other names; and many recurrent growths, formerly called cancers, come properly into this class.

1. *Spindle-celled sarcoma* is of frequent occurrence about the jaws, forming many of the specimens formerly indiscriminately named "osteosarcoma." Under this heading must be included also the "recurrent fibroid" cases, reported by Mr. Holt and Mr. Lawson, in the last of which recurrence took place after three operations, and led—as may be seen in the specimen, which is preserved in the museum of the Royal College of Surgeons of England—to enormous reproductions of the disease in the maxillary and temporal regions.¹

The principal clinical features of spindle-celled tumors of the jaw are rapidity of growth, with invasion of surrounding parts, but no glandular infiltration, at least in the earlier stages. Free removal is essential, because of the tendency to creep along the periosteum beyond the defined tumor, which is common in these cases; and recurrence is frequent. A remarkable feature in the recurrent growths is their tendency to become softer with each recurrence, until the patient dies, worn out, with, rarely, secondary deposits in internal organs. In 1867 I removed a very large tumor, probably of this kind, which in its growth had destroyed the entire body of the lower jaw of a man aged 32. The tumor is in the Hunterian Museum, and a wax model, made soon after its removal, is in University College, London. It is of an irregularly oval shape, measuring antero-posteriorly eight inches, and from side to side about five inches. A tumor had been present in the jaw for some years, but had latterly grown rapidly under the application of quack remedies, and, when the patient came under my notice, he was nearly starved from the projection of a great mass of the growth into his mouth. The jaw, with the tumor, was removed by disarticulating on one side and sawing through the ramus on the other, without any great loss of blood, but the patient died on the sixth day.²

¹ Pathological Transactions, vol. xi.

² Lancet, Dec. 21, 1867.

This tumor has recently undergone a fresh examination by Mr. Eve, who believes it to be an example of a combination of sarcoma with epithelioma, of which, as far as is known, it is a unique specimen.

2. *Round-celled sarcoma* (the encephaloid sarcoma of Cornil and Ranvier, and others) is a more vascular and softer growth, and hence has more of the characters of a "malignant" tumor. It grows very rapidly, invading the skin and forming fungous protrusions, and leads to deposits in internal organs. Many of the recorded cases of "medullary" cancer of the jaw belong to this class. In the Museum of University College, London, is the head of a woman, aged twenty-four, who came under my care in 1868 with an enormous development of round-celled sarcoma in the bones of the face, invading the orbits and cranium. This originated in a growth on the margin of the orbit, which had twice been removed by Sir W. Fergusson, and had again recurred. In a child of five, who was also under my care, a large tumor of the lower jaw had grown in seven weeks, when I removed it with the right side of the lower jaw. Recurrence took place in six weeks, when I again operated, removing a further portion of jaw, with a fungous growth on the skin. Within three months the disease again recurred, and destroyed the patient in less than six months after its first appearance.

3. *Myeloid sarcoma* has long been recognized in relation with the jaws, in which situation it was originally described by Paget. It is found in connection with the alveolus, forming the so-called myeloid epulis, and also in the interior of the lower jaw. Occurring in children or young adults, the myeloid growth springs from the interior of the alveolus, and protrudes between the teeth, which may be displaced. The growth is softer than the fibrous epulis, and more vascular, and occasionally presents characteristic dark spots beneath the mucous membrane. Or, when developed deeply in the interior of the lower jaw, it expands the bone without forming an external protrusion. The development of cysts is not infrequent in the interior of the growth, which may pulsate. A section of the tumor shows the maroon color resulting from hemorrhage within the tissue, so common in myeloid growths.

The question of recurrence in connection with myeloid growths is a very important one; and it may be considered that after complete removal, recurrence does not take place. In 1875, I removed a myeloid tumor from the interior of the lower jaw of a gentleman, aged nineteen, by free gouging, but without dividing the jaw. Recurrence took place, when I again operated very freely, leaving nothing but the thick lower border of the bone, and since then the patient has remained well. A remarkable case in which myeloid tumors of both angles of the lower jaw were present in a boy of seven, was successfully operated on by me some years ago, and I believe that the patient has remained well since.

4. *Alveolar sarcoma* occasionally affects the jaws, and in the Museum of the Royal College of Surgeons of England, will be found a specimen of the kind. This form of sarcoma was called by Wedl "a fibrous form of cancer arising from bone," and should undoubtedly include the cases hitherto described as examples of scirrhus of bone. Mr. Wilkes, of Salisbury, has recorded a case of the kind in a man of fifty, who had a globular mass below the middle of the horizontal ramus of the jaw, adherent to the bone, but movable, and after removal of one-half of the jaw the tumor was found to be inclosed in a thick fibrous capsule connected with the periosteum. A similar growth of the size of a chestnut, with a cavity in the centre, was removed by Mr. Coates from a man of sixty-seven, and both specimens are now in the Hunterian Museum.

5. *Fibro-sarcoma* closely resembles fibroma in external appearance, and generally grows beneath the periosteum. A tumor of the upper jaw in the

Museum of University College, London, is of this nature, springing from the antrum and projecting through its anterior wall, and also through the hard palate.

6. *Chondro-sarcoma*, in which spindle-celled or round-celled sarcoma is mixed with the cartilage which forms the bulk of the tumor, occurs in both jaws, and frequently leads to secondary deposits in the lungs. I have elsewhere¹ recorded the case of a woman, aged forty-four, from whom I removed a large piece of the lower jaw with an enchondromatous tumor of large size, the patient being discharged from hospital twenty-one days after, with the wound quite healed, and with no signs of recurrence. Eleven weeks after being discharged, she was readmitted with a recurrence of disease on both sides of the gap in the lower jaw, and a second operation was performed; but it was found impossible to remove the whole of the growth, which had spread into the pterygoid region. A large, fungating mass formed and protruded externally, and the patient sank on the forty-third day after the second operation. At the autopsy, the mass of growth extended from the zygoma downwards for over seven inches, and was from five to six inches in thickness. Another tumor sprang from the right segment of the divided jaw, and the left side of the tongue and floor of the mouth were largely invaded. The upper jaw was not involved, but only imbedded in the growth, which had forced itself deeply among the neighboring parts, where the veins were filled with firm white clots, though no growth had sprung up in connection with their walls. The tumor on section varied in color, being yellowish-white in some parts, whilst it was red and vascular in others, and mottled with patches of extravasated blood. It weighed two pounds and three ounces. There were two nodules of secondary growth in the left lung, and three larger ones in the right lung. One of these was distinctly seen to be lying in the course of a good-sized branch of the pulmonary artery, whose walls were expanded over it. It did not completely block the lumen of the vessel, and on its surface was a white fibrous deposit.

The mass removed at the first operation consisted chiefly of enchondroma with dim hyaline and fibrous matrix, but interspersed were islets of round-celled sarcoma. The recurrent masses were made up chiefly of round-celled and spindle-celled sarcoma, whilst scattered throughout were isolated portions of cartilaginous tissue with fibrous matrix.

7. The names *osteo-sarcoma* and *osteoid chondro-sarcoma* imply the occurrence of ossification in tumors containing sarcomatous elements, and include the cases hitherto described as "osteoid cancer." A good specimen of the kind is preserved in the Hunterian Museum, and is figured in Howship's "Surgical Observations." The preparation has been macerated, and the part which remains consists of an oval mass of light, cancellous bone, about five inches in its chief diameter, and very slightly connected with the remaining bones of the face. At its lowest part, it preserves somewhat of the form of the alveolar border of the upper jaw; and the incisor, canine, and bicuspid teeth are implanted in it. The frontal bone shows evidence of a secondary growth from within it. The patient was a woman of thirty, and had had the tumor, which is described as "fleshy," for five years, dying from hemorrhage consequent upon extraction of a tooth.

A good example of ossifying sarcoma in the lower jaw, has recently been under my care, in a man of fifty, from whom, in May, 1881, I removed a portion of the horizontal ramus of the lower jaw, cutting well beyond a fleshy tumor which involved it, and which had been growing some months. A recurrence took place, and I disarticulated the jaw on the affected side

¹ *Lancet*, November 24, 1877.

in October of the same year. Shortly after, the disease reappeared on the central portion of the jaw, and I removed a further portion, going beyond the median line, in January, 1882, but was unable to remove the whole of the disease, which had by this time extensively involved the soft tissues of the cheek. The patient died exhausted in April, 1882. In this case the specimens showed ossification taking place in the sarcomatous tissue, and the fungating mass which formed before death would doubtless have developed a complete skeleton similar to that in Howship's case, had the patient's strength held out sufficiently long.

CARCINOMA.—The only form of *carcinoma* affecting the jaws is epithelioma, which is found in at least two varieties, the squamous and the tubular. The position of these depends upon the nature of the normal epithelium of the part: thus the squamous epithelioma is developed primarily in the mucous membrane of the palate and gums, the normal epithelium of which is squamous; whilst the tubular form, with cylindrical epithelium, begins in the antrum or nose, the epithelium of both of which is columnar. Both forms of epithelioma have a great tendency to invade surrounding parts, especially the bones, and hence the difficulty of completely extirpating the disease, except by proceedings of a magnitude which may not be justifiable in the weak condition of the patient.

Squamous epithelioma of the palate and gums begins very insidiously, and its nature is therefore often mistaken at first. Commencing as a small, ragged ulcer on the mucous membrane of the gum, it is often, and probably correctly, attributed to the irritation of decayed teeth or fangs, or to secondary syphilis, but is regarded as of little importance, or is, perhaps, aggravated by the application of nitrate of silver or other irritants. Ulceration of the palate of an epitheliomatous character is more frequently attributed to tertiary syphilis, and even large gaps in the hard palate, caused by epithelioma, are supposed to be the result of a broken-down gumma. But epithelioma of the gums or palate never, I believe, occurs before the age of forty, and more often nearer sixty than fifty, whereas the secondary manifestations of syphilis take place, as a rule, earlier in life, and the tertiary symptoms are much less urgent than those of epithelioma.

By involving the subjacent bone, necrosis is induced in the course of an epithelioma, and here again error may arise if the presence of bare bone be regarded as pathognomonic of necrosis, without considering the cause. Loosening of the teeth is a natural consequence of the invasion of the alveolus, and affords a fair criterion as to the extent of the mischief in the deeper parts. Creeping up the sockets of the teeth of the upper jaw, squamous epithelioma tends to invade the antrum secondarily, and without giving rise to any marked symptoms of antral disease. This form has been described by Reclus¹ under the title of *épithéliome térébrant* (boring or burrowing epithelioma), and Mr. Butlin² has described a case of the kind in a man, aged sixty-two. I do not agree with that gentleman, however, in regarding the disease as extremely rare, for I have had at least three cases recently under my care, in which the gums and palate were primarily affected, but in which the antrum was found to be extensively involved when it was opened up.

The treatment of squamous epithelioma of the jaws, as of that in other parts of the body, consists in prompt and free removal of the affected part. When the disease is confined to the gum and margin of the alveolus, comparatively mild proceedings may be justifiable in the first instance; but if the disease has gone at all deeply, removal of the upper, or of a large por-

¹ Progrès Médical. 1876.

² Pathological Transactions. 1881.

tion of the lower jaw, should be undertaken without hesitation. Even then it may be impossible to clear away the whole of the disease, which, as in Mr. Butlin's case, may "extend through the lower wall of the orbit to the eyes, into the sphenomaxillary fossa, and up between the temporal and masseter muscles and beneath the temporal aponeurosis." Mr. Lawson¹ has advocated, after removal of the jaw, the use of caustic paste, and the destruction of the skin covering epitheliomatous growths of the antrum, as being the most efficient mode of treatment, and I believe with good ground; but the drawback is of course the terrible deformity resulting, which to many persons would be worse than the disease.

The *tubular form of epithelioma* may originate in the antrum, or, commencing in the nose, may secondarily invade the antrum. The growth is characterized by great rapidity of development, and softness, and the surrounding structures are apt to be rapidly involved. Hence tumors of this class were formerly considered as examples of soft cancer. When beginning on the nasal mucous membrane, the stoppage of the nostril is generally the first symptom noticed, and possibly temporary relief may be obtained by the removal of the so-called polypi. When the disease begins in the antrum, it leads to a rapid expansion of the cheek, with stretching and thinning of the skin, which eventually becomes involved, and ulcerates, giving exit to a fetid, watery discharge, and permitting the formation of a yellow, fungous growth. The nose and the orbit become secondarily involved, and the growth is apt to find its way into the several fossæ of the outside of the skull.

In the treatment of this form of disease, the remarks already made on the treatment of squamous epithelioma apply with double force. But the question often arises, when it is obviously impossible to hope for such a complete removal as shall insure future immunity from relapse, whether any operation may be undertaken with the view of giving relief and prolonging life. I have no hesitation in recommending an operation undertaken with these objects, in suitable cases, because I have found that I have been able to give enormous relief, both bodily and mental, to patients with incurable tumors of the jaw, by getting rid of the mass of the disease, which, by its size and unsightly appearance, was a daily burden; and have prolonged life for some months, in comparative comfort, by giving space in which the fresh formation could lodge itself without interfering with deglutition or respiration, and without causing the sufferer to be an eyesore to himself as well as to others.

OPERATIONS ON THE JAWS.

In all operations upon the jaws, the greatest care should be taken to avoid extensive scarring of the face, and the infliction of unnecessary deformity, particularly by breaking the line of the lower jaw. Incisions for the relief of inflammation or the evacuation of matter, and punctures for emptying cysts or the antrum, should invariably be made within the mouth. Extraction of sequestra may be performed in most cases more conveniently through the mouth than by external incision, though the surgeon may occasionally avail himself of existing sinuses. The removal of epulis in all its varieties can be readily accomplished through the mouth, if the operator is provided with proper bone-forceps of various kinds, and even large portions of the jaws may thus be removed with success. The late Mr. Maunder,² on two occasions, removed large portions of the right side of the lower jaw with the surround-

¹ Clinical Society's Transactions. 1873.

² Med. Times and Gazette, July, 1874.

ing tumor, without any external incision, separating the soft parts with a raspatory, and sawing the bone in front of and behind the tumor. The principal difficulty in these operations was not so much the separation of the tumor, as its "delivery" through the mouth, which was slightly split in one instance. Fortunately the hemorrhage in both cases was slight, and the patients did well, but another surgeon was less fortunate, and lost his patient by secondary hemorrhage; and considering the close proximity of the facial artery, and the necessary division of the inferior dental artery, this is not to be wondered at. For my own part, I do not think that the extra trouble and risk of the proceeding are balanced by the absence of a scar, which in the majority of cases need not involve the lip, and, if properly placed, will be nearly invisible afterwards. The same may be said of the so-called "sub-periosteal resections" of the upper and lower jaws. In cases of necrosis, it is of course advisable to preserve all the periosteum, and in extracting a sequestrum, it may be occasionally necessary to turn aside the soft parts with a raspatory; but any systematic stripping of periosteum from a jaw involved in a tumor, is not only impossible in most instances, but, if undertaken, will only leave shreds of periosteum with possibly some portions of diseased tissue attached. In one case in which I took considerable trouble to preserve the muco-periosteum of the palate, when removing the upper jaw, the flap proved a great annoyance to the patient during convalescence.

REMOVAL OF THE UPPER JAW.—Partial or complete removal of the upper jaw may be most conveniently performed as follows, the incisions being extended as the gravity of the case may indicate. A straight incision through the median line of the upper lip, and prolonged on one side of the *columna nasi* into the nostril of the affected side, will allow the tissues of the face to be readily dissected up from the jaw, so as to expose completely the front wall of the antrum. This may then be perforated and removed with bone-forceps, so as to permit of the extraction of a tumor from within, or room may thus be found for the removal of large portions of the palate.

In a case of more extensive disease, in addition to the incision already made, one should be begun near the inner angle of the orbit, and be carried down by the side of the nose and around the ala into the nostril. This will allow of further reflection of the soft tissues, and more complete exposure of the bone, so that it would be easy to cut away large portions of the jaw with suitable bone-forceps; or a small saw could be readily carried transversely from the nostril at any desirable level, so as to preserve either the palatine or orbital plate.

For removal of the entire upper jaw, it will be advisable to make an additional incision below the orbit from the inner angle to the malar bone, following the natural curve of the skin-markings of the part. This incision may be prolonged on to the malar bone as far as may be necessary, and may be met at its extremity by another at right angles to it in very extensive disease of that bone. The flap of skin is now to be reflected outwards, and this method has the great advantage of preserving the facial nerve, and of dividing only small branches of the facial artery.

Division of the bone will be required at three points: (1) the palate, (2) the nasal process of the maxilla, and (3) the malar bone; and these sections may be made with the saw or bone-forceps, or more conveniently with both. A narrow saw, with movable back, is to be passed into the nostril, and the hard palate divided with the alveolus, from which a central incisor tooth should have been previously extracted. The saw should be kept parallel to the floor of the nostril, and there need be no fear of damaging the pharynx with its extremity. The movable back allows the blade of the saw to pass through

the bone into the mouth, thus dividing the whole of the hard palate without the splintering which usually follows division with bone-forceps. The soft palate escapes injury from the saw, and any attempt to dissect off and preserve the soft covering of the hard palate is futile. The nasal process of the maxilla may be conveniently notched or completely divided with a small saw, and the saw is next to be applied to the malar bone, parallel to and immediately in front of the masseter muscle. This cut will then run into the spheno-maxillary fissure, and the prominence of the cheek will be preserved; but in cases of very extensive involvement of the malar bone, it will be necessary to remove the whole of it by dividing the zygomatic process, and the frontal process at its junction with the frontal bone.

Before dislocating the bone, it is well to divide the soft palate transversely, close to its attachment to the hard palate, which can be readily done from the mouth. With a pair of angular bone-forceps, the three cuts made with the saw should then be thoroughly cleared, and it is convenient to take them in the reverse order, viz., malar bone, nasal process, palate. The bone-forceps, when dividing the palatine attachments, may be conveniently used to tilt the whole jaw forward, and the lion-forceps should then be employed to grasp it, and forcibly depress the mass, while the scalpel is used to divide the infra-orbital nerve behind the bone so as to prevent its being stretched, and also any soft tissues which may remain attached to the jaw. The hemorrhage, which is often sharp for the moment, is best checked temporarily by thrusting a sponge into the opening, and this after a few minutes' pause may be withdrawn, in order to allow of the application of the actual cautery at a black heat, so as to sear any bleeding vessel. A careful examination should be made to see that all the diseased tissue is removed, when caustic paste may be advantageously applied to any doubtful parts; after which the flap of skin is to be replaced and fixed with fine wire sutures, and with harelip pins for the lip, the red margins of which are best approximated by a fine silk stitch. Unless the oozing of blood is so considerable as to necessitate plugging the wound, it is, I am sure, better not to introduce any lint beneath the cheek, since it only collects discharge and becomes very offensive in a few hours, when its withdrawal is both difficult and painful. Thorough sponging with a strong solution of chloride of zinc (forty grains to the ounce), and subsequent dusting with iodoform, will keep the parts sweet for some days, after which free syringing with antiseptic lotions is useful, and for this purpose nothing answers better than the continuous stream of the siphon nasal douche.

Removal of both upper jaws has been performed a few times, and in very severe operations of the kind recourse may be had to Trendelenburg's method of performing tracheotomy and plugging the trachea by an India-rubber tampon around the tracheal tube. This instrument is somewhat unsatisfactory, however, for if blown up sufficiently to really plug the trachea, it is apt to produce urgent dyspnoea by pressure on the rings of that tube; and a more satisfactory method will be found to consist in performing tracheotomy, and then plugging the upper part of the pharynx with a sponge, to which a string is attached for safety's sake.

Dr. Goodwillie, of New York, and other surgeons, have employed the "dental engine" in operating upon the upper jaw, and profess to have found their operations greatly facilitated by the use of this machine. There can be no question that great rapidity may be gained in the use of various drills and saws ingeniously adapted to the engine, but experience is wanting, in England, at least, in its use, and the great rapidity of its action would appear to be not unaccompanied by danger.

REMOVAL OF THE LOWER JAW.—In removing portions of the lower jaw, the incision should as far as possible be placed below its border, so that the cicatrix may be hidden. An incision from the median line to the angle, thus placed, will divide the facial artery immediately in front of the masseter muscle, and both ends should be at once secured with a ligature. The tissue of the face can now be dissected up, and the cavity of the mouth opened by dividing the mucous membrane close to the gums, when any part of the body of the jaw can be removed by making a section with the saw on each side of it. In making these sections, it is better not to complete one before the other is begun, because of the loss of resistance consequent upon breaking the continuity of the bone; but each cut, being carried nearly through the bone with the saw, may be conveniently finished with the bone forceps. Should it be necessary to prolong the incision beyond the median line, and to remove the symphysis, care must be taken to guard against the falling back of the tongue by having a stout thread passed through it, upon which traction may be made. The mylo-hyoid muscle and mucous membrane inside the bone can then be divided, and the piece removed, but whenever possible the alveolus alone should be divided and the border of the jaw preserved. In removal of one-half of the lower jaw, it will be advisable to divide the lower lip in the median line; for though it is possible to perform the operation without this, yet if the disease is at all serious, it unnecessarily complicates the operation to save the lip, which reunites readily enough. The incision should then be carried at right angles to that in the lip, along the lower border of the bone as far as the angle, and then upwards to near the lobule of the ear. This will necessarily divide the facial artery, but no important branches of the facial nerve, unless prolonged into the parotid gland. The tissues of the face and the masseter being dissected up from the bone or tumor, the jaw is to be divided at a convenient point, a tooth having been previously extracted. The scalpel is then to be carried closely along the inner surface of the jaw, to divide the tissues forming the floor of the mouth, and care must be taken not to detach or damage the sub-lingual gland. The cut end of the jaw, being grasped with the lion-forceps, can now be everted so as to bring the internal pterygoid muscle into view, and this must be dissected from the bone. Should the disease be of a non-malignant character, and not involve the articulation, the ramus of the jaw should be sawn across in preference to disarticulating, and even when the tumor encroaches very closely upon the joint, it may be possible to divide the neck of the condyle and the coronoid process separately, with bone forceps.

In order to disarticulate the condyle, the soft tissues should be held out of the way with spatulas, when the jaw, being firmly grasped with the lion-forceps, is to be depressed so as to bring the coronoid process forward, and to allow division of the insertion of the temporal muscle. This is sometimes rendered difficult by an unusual length of the process, or by its being jammed against the malar bone by the bulk of the tumor. In this case it may be necessary to cut off the coronoid process with bone forceps, or to break it by force. The coronoid process having been cleared, the depression of the jaw from before backwards is to be continued, in order to throw the condyle forward; but great care must be taken not to rotate the jaw outwards, lest the internal maxillary artery should be stretched around the neck of the bone, and be either torn or divided, when the hemorrhage would be severe and difficult to arrest. The condyle being made prominent, the knife is to be carefully applied over it, when the bone will start forward, tearing through and bringing away with it a portion of the external pterygoid muscle. The knife must not be used to divide the muscular fibres, which bleed less if

torn, but may be employed to divide the inferior dental nerve, so as to save it from being pulled out of the bony canal.

When from the nature of the tumor the leverage of the jaw is lost, and consequently disarticulation of the condyle becomes difficult, recourse may be had with great advantage to the broad spatula recommended by Professor Gross for disarticulating the condyle from the glenoid cavity. In this way the bone may be forced from its socket, and the risk of hemorrhage from the internal maxillary artery be completely avoided.

Any bleeding vessels should be secured with ligatures, when the lip should be united with harelip pins and the wound with sutures, care being taken to leave a dependent opening for the discharges.

CLOSURE OF THE JAWS.

Inability to separate the jaws may be temporary or permanent. In the former case, setting aside cases of *trismus* from nervous affections, the cause is contraction of the muscles of mastication, especially the masseter, due to the irritation from an uncut wisdom-tooth. Owing to want of room between the second molar and the ramus of the jaw, or owing to some malposition of the tooth itself, the wisdom-tooth is unable to assume its normal position, and by the pressure which it exerts on the neighboring structures sets up irritation, which induces a state of tonic spasm of the masseter and internal pterygoid muscles.

The majority of these cases occur, as might be anticipated, about the age of twenty, and the diagnosis is easy, unless very great swelling, and possibly abscess, should have supervened and obscured the nature of the case. The treatment consists in administering chloroform thoroughly, so as to relieve the spasm somewhat, and allow of the introduction of a screw-gag between the teeth, in order to separate the jaws. This must be done slowly and steadily, so as not to inflict injury upon the front teeth, and the back of the jaw may then be reached. If the wisdom-tooth is presenting in its normal position, a free division of the gum over it, and removal of the flaps thus made with scissors, will be sufficient treatment, if the patient will patiently bear a little inconvenience for a time. But when there is obviously not space for the wisdom-tooth to be erupted, room must be made by extracting the second molar, unless the wisdom-tooth itself can be reached and extracted, which is seldom the case. Occasionally the extraction of the upper wisdom-tooth, against which the lower wisdom-tooth is pressing injuriously, may completely relieve the trouble. In whatever way room is given, relief is sure to follow, and in the course of a few hours the spasm of the muscle passes off.

Permanent closure of the jaws may depend upon destruction of the temporo-maxillary articulation, or more frequently upon the contraction of cicatrices in the cheek, following ulceration or sloughing. This latter condition is frequently the result of gangrenous stomatitis occurring in childhood, in which case destruction of the whole thickness of the cheek not unfrequently takes place; but the same result may follow an attack of fever, etc., at any age. When the mischief is confined to the lining membrane of the cheek, the soft parts become firmly adherent to the alveoli of both jaws, and a rigid cicatrix of fibrous tissue, in which bone not unfrequently develops, binds the jaws firmly together. Under these circumstances the patient is often nearly starved, for he can only rub soft food between the teeth, or push it with the finger behind the teeth, on the unaffected side. In the cases where destruction of the cheek has taken place, although the deformity is more

unsightly, the patient is generally able to feed better, particularly if one of the molar teeth is wanting.

The treatment of cicatrices by simple division within the mouth, is perfectly futile, for although wedges may be employed for a time to keep the jaws apart, they will certainly be drawn together by the rigid contraction of healing. In order to secure improvement in the patient's condition, it is necessary to prevent the adhesion of the cheek to the alveoli, and to restore as far as possible the pouch of mucous membrane between them. This can only be done by adapting to the teeth metal plates or shields which can be constantly worn after free division of the cicatrices, and which, reaching well beyond the gums, can prevent adhesion taking place between the cheek and the alveoli. After a long time, a formation of mucous membrane takes place in the sulcus thus formed, and the plates may then be dispensed with in the daytime, but must be worn for many months at night. It is obvious that treatment of such a protracted nature cannot be carried out in children, and that the coöperation of an able mechanical dentist is essential for success. The method is applicable only to cases in which the whole thickness of the cheek is not involved; but the extent of the adhesions is comparatively unimportant, since the plates can be adapted to both sides of the mouth, as in a case of my own.¹

In the case of unilateral adhesions, division of the lower jaw in front of the cicatrices, and the formation of a false joint, give very good results. Esmarch removed a wedge-shaped piece of bone, so as to secure fibrous union with free mobility, while Rizzoli contented himself with dividing the jaw from the mouth, and trusted to the subsequent movements to establish a false joint. I have no experience of Rizzoli's method, but, having twice performed Esmarch's operation, have every reason to be satisfied with it. The operation is a very simple one, an incision along the lower border of the jaw easily admitting of the use of a narrow saw for the removal of a wedge of bone, the base of which should be below. The only point of importance is that the section should be made thoroughly in front of the cicatrix in the cheek, for if this is not attended to, the operation will fail. The operation is applicable mostly to cases in which one side of the mouth is affected, and in two or three weeks restores to the patient a very useful, though one-sided, amount of masticatory power, with very little suffering or annoyance. One side of the jaw remains of course permanently useless, and there is necessarily some deformity left, but the relief is permanent. A patient upon whom I operated in 1864, called on me in 1880, to show how satisfactory the movement of her jaw continued.

Inflammation of the temporo-maxillary articulation may lead to complete ankylosis of the joint, and consequent immobility of the jaws. Arthritis occurs as the result of injury, or of constitutional affection. In children it follows the exanthemata, and is often connected with suppuration in the tympanum. In adults, it is of a rheumatic or gouty, and therefore more chronic, character. Rheumatoid arthritis also affects the temporo-maxillary articulation, and leads to great suffering from the painful movement of the jaw. In two patients I have noticed the characteristic enlargement of the condyle and neck of the bone, with protrusion of the chin to the opposite side, described by Robert Adams in his great work on the subject. This disease does not, however, lead to the osseous ankylosis, or synostosis, which is met with in cases of common arthritis with suppuration.

In acute inflammation of the joint, leeching and fomentations, with timely evacuation of pus, would be the appropriate treatment. In the more chronic forms, attention to the constitutional diathesis, and the frequent application

of blisters over the joint, offer the best chance of relieving the patient, but the treatment is eminently unsatisfactory. Dr. Goodwillie,¹ of New York, has ingeniously proposed to produce extension between the two surfaces of the temporo-maxillary articulation by fitting blocks upon the molar teeth, and by then drawing up and fixing the chin; and he gives several cases in which a cure was thus brought about. The ankylosis resulting from articular inflammation may be fibrous or osseous, and the diagnosis can only be made when the patient is thoroughly under the effect of an anæsthetic. Fibrous adhesions may be broken by forcibly opening the jaws, but very great subsequent care will be necessary to prevent reunion, and it may be better to perform Esmarch's operation of division of the bone in front of the angle. Dr. Goodwillie² has recorded two cases in which he succeeded in thus breaking adhesions with the best results.

In cases of ankylosis of the temporo-maxillary joint, the operation of excising the condyle of the jaw has been performed in a few instances. The first removal of the condyle was by Professor Humphry,³ of Cambridge, and was undertaken for chronic rheumatic arthritis. He exposed the condyle by a curved incision from the side of the orbit, across the zygoma to the ear, passing a little above the temporo-maxillary articulation; and by a second incision from the termination of the first, directly upward in front of the ear and across the zygoma again, avoiding the temporal artery. The flap thus made was reflected, and the neck of the condyle cut through with a narrow saw. Dr. Bottini,⁴ in 1872, communicated to the Royal Academy of Medicine at Turin, the case of a lad of seventeen, who had fallen on his chin when seven years old; inability to open the mouth gradually set in, so that in a few months he was quite unable to separate the jaws. Bottini opened the mouth forcibly during anæsthesia, and inserted a wedge. This however was so troublesome to the patient that it was removed, and resection was determined on. An incision was made on one side, and the head of the jaw-bone, after the periosteum had been separated, was removed with the chisel and hammer. This had no appreciable effect, and it was only after the operation had been repeated on the other side that the jaw could be freely moved. In neither of these cases was there true synostosis, such as may be seen in a specimen of a negro's head in Guy's Hospital Museum, and such as existed in a case successfully treated by Dr. James Little,⁵ of New York, in 1873. The patient was nineteen years of age, and had some years before suffered from suppuration of the temporo-maxillary articulation, leading to ankylosis. Dr. Little made an incision along the lower border of the jaw, and turned up the masseter, when the neck of the condyle was seen to be very much enlarged, and continuous with the temporal bone. A trephine half an inch in diameter was then applied, and a button of bone three-eighths of an inch in thickness was removed. The portion of bone on each side of this opening was next cut through with a chisel, and the neck of the condyle cut away piece by piece, so as to leave no portion projecting from the temporal bone. The result was quite satisfactory.

A similar operation, but performed by a different method, was successfully undertaken by Dr. Robert Abbe,⁶ of New York, on a boy of ten who had suffered from otitis media and suppuration of the joint seven years before. A longitudinal incision was made in front of the ear, and a transverse one, meet-

¹ Archives of Medicine, vol. v. June 3, 1881.

² Monthly Review of Dental Surgery, October, 1875.

³ Association Medical Journal, 1856.

⁴ British Medical Journal, August 31, 1872.

⁵ Transactions of New York State Medical Society. 1874.

⁶ New York Medical Journal, April, 1880.

ing the upper end of the first, was carried along the lower border of the zygoma. The parotid and the facial nerve were drawn down, and with a periosteal elevator the posterior fibres of the masseter were cleared away, and the articulation exposed. A narrow osteotomy chisel was now applied to the neck of the condyle, and carefully driven half through the bone, when by forcibly opening the mouth the bone was broken through. The neck of the condyle was then carefully removed piecemeal, but the condyle itself was left *in situ*. The result was satisfactory. Sédillot¹ mentions that, in a case of true ankylosis of the temporo-maxillary articulation, M. Grube, in 1863, carried a straight chisel through the mouth to the neck of the jaw, which he broke by hammering. Some months later he divided the masseter subcutaneously, and the cure, by the formation of a false joint, was permanent. In 1879 I performed the same operation in a child of six, but the results were unsatisfactory. Suppuration was set up, and required an external opening, and the movement, which was free at first, became as limited as before the operation. It would appear, therefore, that mere division of the neck of the bone does not offer such good prospect of a permanent false joint as removal of the neck or the condyle, though these operations are necessarily more severe.

Esmarch's operation, performed in front of the masseter, is of course as applicable to cases of ankylosis from disease of the joint as to cases of cicatrix, and Fischer² appears to have performed the operation on both sides of the jaw, in a case of bilateral ankylosis of the temporo-maxillary articulation, with very good result, the patient obtaining complete and useful control over the central, movable portion of the jaw.

¹ Médecine opératoire, tome ii. p. 30.

² British Medical Journal, June 1, 1872.

SURGERY OF THE TEETH AND ADJACENT PARTS.

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DENTISTRY, although a specialty of surgery, has become almost a distinct science—distinct in the fact that it may be taught independently, and also in the fact that heretofore many of its most skilful practitioners have reached the highest excellence without any knowledge of general surgery. Nevertheless, it is a department of the great science and art of medicine, and its highest possible attainments must have the more comprehensive science for their foundation.

Its best results have been due so much to the dexterous manipulative ability of its practitioners, that the general surgeon has regarded it as a mechanical trade, and has ignored it in the acquirement of his education.

The science of dentistry is medical, surgical, and prothetic. Dental therapeutics includes a class of operations which are not taught in the medical schools, and are not practised in the offices of physicians and surgeons, but the successful performance of which requires special appliances, special surroundings, and mechanical and æsthetic qualities of a high order; hence, by universal consent, these operations have been assigned to a special class of practitioners, who, by limiting their range of action, have perfected themselves in their chosen sphere of work. Every operation of oral surgery requires a delicacy and precision of touch which is rarely found in the practice of general surgery. There is no preparatory training which the general surgeon could add to his other necessary acquirements, to perfect himself in the dexterous use of instruments, at all comparable to a mastery of the operations in dentistry.

SURGERY OF THE DECIDUOUS TEETH.

LANCING THE GUMS.—Surgical interference is frequently demanded even before a tooth is erupted in infancy. Localized stomatitis may be relieved in many cases by *lancing the gums*, an operation, however, which is not always indicated, and which has undoubtedly been many times resorted to injudiciously. If the tooth or teeth suspected to be the cause of local irritation, as well as of constitutional disturbance, are not far advanced and ready to erupt, lancing the gums may do more harm than good, the incision perhaps closing with cicatricial tissue, which may cause subsequently greater disturbance than if no incision had been made. "When tumefaction of the gum is dependent on tooth eruption, and the child is of healthy condition, a certain evidence is found in the glistening character of the swelling, the part immediately over the tooth or teeth looking stretched and feverish. This tense look is nearly always present, and may, under all circumstances, be esteemed

an indication demanding the lancet." Lancing in such cases, if properly performed, yields almost instantaneous and complete relief.

The incision should be made with reference to the shape of the tooth; thus, for any of the anterior teeth, either above or below, the cut should be made on a line with the cutting edge of the tooth, and deep enough to strike the enamel. For the canine teeth and those posterior to them, the crucial incision is better, making the lines diagonal to the jaw rather than parallel or at right angles with it. Undue hemorrhage need not be apprehended. The loss of a little blood is ordinarily rather to be desired than otherwise.

EXTRACTION OF DECIDUOUS TEETH.—The mere removal of a temporary tooth when dentition is proceeding regularly, and the period has arrived for it to be shed, is an operation of minor character. In normal dentition, the waste of roots and surrounding processes goes on relatively and simultaneously with the advance of permanent successors, and, without interference, the temporary crown will literally be shed from the gum; but abnormal second dentition is of such frequent occurrence, together with diseases which attack the crowns and roots, that extraction in advance of shedding is often demanded.

If there be no disease, such as a painful pulp exposed by caries, or an ulceration or abscess following such exposure, it is unwise to remove a temporary tooth, unless its permanent successor is emerging from the gum beyond the boundary line of the dental arch. The normal order is to follow and succeed to the exact position occupied by the temporary tooth. The abnormal is an emergence from the gum, either within or without the arch, while the temporary tooth is still in place. As soon as such abnormality is discovered, extraction of the deciduous tooth should be immediate. The extraction of deciduous teeth that have remained firm in the jaw after the period of shedding has been reached without any evidence of the emergence of their successors, is not indicated. Sometimes a permanent tooth never erupts, and the sacrifice of a deciduous tooth which has occupied its position is an irrecoverable loss.

It is very common for there to be a want of development or increase in the size of the jaw, commensurate with the demand for more room which the growth of large permanent teeth, to occupy the place of their small predecessors, demands. The result is an apparent necessity for removing two temporary teeth to make room for one permanent tooth. This is frequently the case as the six front teeth in either jaw are erupting, and whenever the difficulty has been met by extracting two teeth to make room for one, it has almost inevitably created a crowding out of line, and an irregularity in the permanent dental arch. Only in very rare and exceptional cases should such a procedure be adopted, and it is especially desirable that each of the canine teeth should be retained until the certainty of the eruption of its successor has been assured.

When it becomes necessary to extract the deciduous molars long in advance of their period of shedding, care should be taken that the alveolar process be not grasped in the forceps, lest the germ or partly-developed crown of the permanent tooth should be included and removed, which would be an irreparable injury. The premature extraction of temporary teeth has been strenuously opposed by some, because it has been believed that contraction or shrinkage of the jaw would follow; but this view has been found to be fallacious, because the maxillæ develop quite independently of the teeth. The teeth, it will be remembered, grow upon, not out of, the jawbone, and the alveolar processes form and increase about the roots of the advancing teeth. Alveolar processes grow up with the teeth, and are absorbed and waste away when

the teeth are gone. The maxillæ, during the process, develop up to the type of their inheritance, irrespective of the changes in the alveolar processes.

SURGERY OF THE PERMANENT TEETH.

EXTRACTION OF PERMANENT TEETH.—The removal of a tooth is rarely a difficult operation, when its anatomy and that of its surroundings are apprehended; but there is no operation in dentistry which requires more firmness, self-control, and confidence in one's own ability. A timid, nervous, unstable hand will be almost certain to do damage, sometimes almost irreparable.

The roots seldom penetrate the true maxilla to any extent, and the surrounding walls of alveolar process are so vascular, elastic, or frail, that they give way more rapidly than might be supposed. Nevertheless, there are exceptional cases which tax the utmost ingenuity and strength of the operator to manage. The most difficult teeth to extract are ordinarily the cuspidati of either jaw, and the first two molars of the upper jaw. The difficulty with the canines is owing to their extremely long roots, and with the molars to their having three roots each, which generally diverge from the crown so that the diameter of the socket at the neck of the tooth is less than the extreme breadth at the apices of the roots. It is indeed a wonder, sometimes, that they ever come away without tearing the alveolar process along with them. The teeth which are removed most readily are the lower incisors, and after them but little difference is seen in the extraction of the upper incisors and the bicuspidi of both upper and lower jaws. All of these last named have, substantially, but one nearly straight root, and all are of about the same length. The first two molars of the lower jaw, each with two roots, are more readily removed than the corresponding teeth of the upper jaw, while the third molars above and below are taken out with comparatively little strength.

The propriety of the removal of teeth must be determined entirely by the judgment of the operator. In the present advanced state of dental skill, the absolute necessity for the extraction of a tooth ought to be very rare. As patients avail themselves of the benefits of dental science, so will the extraction of teeth which are firm in the jaw become more and more infrequent.

Experience has shown that the simplest and best instrument for extraction is the forceps. Formerly the turnkey was the sole instrument employed, but the principle of its application is so ill-adapted to the end required, that any directions for its use are unnecessary. It is a dangerous instrument to use in almost all cases, and has been superseded by such as are admirably adapted to their purpose. The specialist may have, with some slight advantage, a peculiar forceps adapted to each tooth in the mouth, and the variety of these forms is now such that each different kind of tooth may have its special forceps; but for the general surgeon such an array of instruments is quite unnecessary.

Dr. Hasbrouck, of New York, who has for sixteen years made a specialty of extracting teeth with the aid of anæsthesia induced by the administration of nitrous-oxide gas, finds that he can extract all the teeth of both upper and under jaws with but two pairs of forceps. With a forceps of bayonet-shape, with straight handles, and with beaks alike of medium width, every tooth of the upper jaw can be removed; and what is called the "universal lower-molar forceps" may be used for all the teeth of the lower jaw, provided that the blades or beaks are not too wide. An additional set of two pairs may be added with advantage, viz., one nearly straight, and one curved almost to a right angle, both with quite narrow beaks; these are more appropriate to the small teeth above and below than the instruments first described. Any number

more than these will be absolutely required only to suit the fancy of the operator, or to meet some extraordinary occasion.

In extracting any of the upper teeth, the best position is with the head of the patient against the left breast of the operator, who places his left arm around the head, and clasps it by putting his fingers in the mouth and against the upper jaw. For the lower jaw the operator should stand behind, with the patient's head against his stomach; thus, with his left hand holding the chin and his thumb in the mouth, the jaw is held firm while extracting. Many authors lay much stress upon lancing the gum previous to the application of the forceps, but in the experience of those who have the largest practice in this specialty, lancing is rarely required. Forceps as now made have thin edges, and in using them should always be firmly forced up the surface of the tooth until they reach the alveolar process; this act will drive away the gum and render lancing unnecessary. No special directions can be given for the manner in which a tooth should be drawn, except that luxation or rotation may be of a little advantage with teeth that have single roots; but rotation with the molars is impossible. The strength required and the direction of movement must be left to the judgment of the operator, as he feels the necessity at the moment.

Sometimes it is impossible to extract an upper molar without resorting to an intentional removal of the buccal wall of the alveolar process, but this should only be a last resort. If, in the effort to extract any tooth that has a living pulp (particularly a molar), it should be broken off, the immediate results may be serious. An upper molar with strong surrounding walls, broken in this way, may be almost impossible of removal, and the fractured and exposed pulp will cause violent pain. The best immediate treatment will be the use of the actual cautery, if it can be applied; otherwise, a minute quantity of arsenious acid upon a small pledget of cotton, dipped in oil of cloves, will give relief.

The removal of small portions of the process accidentally, is not uncommon, and serious results need not be apprehended. That which has come away would be absorbed within a short time if it had been left. Neither is there to be any danger anticipated from prolonged hemorrhage.

Hemorrhage for a few minutes is to be expected, but if profuse and prolonged, a plug of lint with tannin placed in the socket, and a compress to hold it, will soon stop the bleeding.

Sound teeth should never be extracted to make way for artificial ones. One, two, or three sound teeth which are firm in the jaw, will be worth more for mastication than all the artificial substitutes that can be employed.

IRREGULARITIES OF THE TEETH.—With advancing civilization there is an apparent increase of deformities of the dental arch. In the higher social scale, it is exceptional to find a young person with a perfectly developed and regular row of teeth set in a well-formed and rounded arch. More commonly, departures from this type will be found of every grade, more or less pronounced, exhibiting some of the phases of narrowed jaws, with teeth protruding, overlapping, and crowded in every conceivable state of disorder. In many instances, the cause has some direct connection with other evils that seem inseparable from a state of high civilization.

A close observer for a generation has seen a multitude of cases which had no apparent local cause, were not of hereditary origin, and could only be attributed to constitutional conditions developed in the individual. As a general statement, the finer the nervous organization—the more precocious, or brilliant, the intellect—the greater will be the tendency to dental deformity.

The converse is true of feeble-minded people who, having a fair physique, show well-rounded jaws and regular dental arches.

Many peculiarities are of inherited origin as far as the individual is concerned, but what may have caused the initial departure from a normal type in preceding generations, it is impossible to determine. More readily, perhaps, than any other deformities of the human organization, are dental irregularities transmissible, and departures from a normal type in the parents reappear in the children in an exaggerated form.

Irregularities that require treatment are never seen in the deciduous teeth. The deciduous dental arch is always well formed and symmetrical. It is only in the second set that deformities make their appearance; and it is exceptional that such peculiarities can be foreseen and prevented. It cannot be determined with any certainty, before eruption, that a dental arch is going to be abnormal, the causes being generally hidden and remote.

The normal type of the dental arch describes a regular line; the arch may be wider or narrower, varying somewhat in individuals or races, but the line will be an easy, graceful curve, without break or tendency to form an angle. Within certain limits, a narrow dental arch, as associated with certain features, may become the perfection of beauty; while with another form of head and face, the widest development may be equally pleasing. That which is recognized now as the standard or full measure of beauty, as well as of utility, is not unlike that which existed in the remotest historic ages, nor different from that which is now exhibited among all communities not degenerated by luxury or vice.

Abnormalities include such a shape of the arch as is not in harmony with the surrounding features, all crowding and twisting of the teeth, and all departures from a regular line in their positions. One form of irregularity seems to be due to unwise or premature extraction of the deciduous canines of the upper jaw. In the ordinary course of nature, these teeth should be the last to drop out. If extracted long anterior to their period of shedding, the permanent bicuspid is liable to encroach upon the domain of the canines, and thus deprive them of their place in the arch. Such a malposition can be foreseen and prevented. Another abnormality of the superior dental arch which can be prevented is the result of thumb-sucking, or its equivalent, in the earlier years of childhood. The effect of this habit is to protrude all the teeth in the front part of the mouth. This deformity will not show itself until the eruption of the permanent teeth, sometimes even after the practice which caused it may have ceased.¹ But a large proportion of dental irregularities cannot be predetermined with certainty, even where there is an hereditary tendency, and can be corrected only when they develop. An observer with limited experience may often be misled by the appearance of teeth as they first erupt. They may seem to be growing out of the line of the arch, and it may be thought that a permanent irregularity is inevitable. But many such cases need no interference; if left to themselves the teeth will acquire regularity, and will often assume their true places unless the occlusion of the antagonizing teeth prevents them.

But interference is demanded as soon after eruption as it becomes certain that a deformity is inevitable. There is then no longer justification for delay, for after that period every year increases the difficulties, both pathological and mechanical, and prejudices the stability of the dental apparatus. But all irregularities in the position of the teeth are not deformities which

¹ In one instance which came under the author's observation, a mother of good social position had nursed from her breast a daughter until the latter was nine years old, the result being that the girl's six upper front teeth were protruding so that her lips could not be closed.

demand treatment; there are many departures from a normal type where neither the utility nor the beauty of these organs, nor the symmetry of surrounding features, is seriously affected by the malposition. The regulation of teeth, moreover, often involves the wearing of fixtures which cannot be removed and cleansed as frequently as the health of the mouth demands; their continued presence may provoke caries of the teeth; and prolonged treatment may seriously injure the nervous system; wherefore the regulation of teeth should not be undertaken without due consideration.

Regulation of teeth may be undertaken, under favorable circumstances, at any age short of full maturity; but, all things considered, the most desirable period to begin the correction of an extensive irregularity, is when the cuspidati and second molars are fully erupted. The occlusion of the teeth is an important factor in determining the permanency of the change. All attempts at correction, at any age, will be futile, unless the antagonizing teeth, upon occlusion, will serve to hold the displaced teeth in their new positions. Success in treatment is based upon the fact that the teeth are placed upon the maxillæ, surrounded by vascular, elastic, bony processes, which are easily moved or absorbed under pressure, and that reproduction of bone will follow, and will make the teeth solid in their new locations. The possibilities under favorable conditions, within certain limits, are almost unbounded. Narrow jaws may be widened, protruding jaws made to recede, individual teeth moved considerable distances, and teeth elongated or shortened, or twisted in their sockets. The success of skilful efforts in this direction has been triumphant.

Some of the most marked cases are where the face is deformed by a protruding or receding jaw, either upper or lower. Strictly speaking, when this occurs with the upper jaw, it is not the maxilla which is at fault, but rather the whole dental arch. Such a condition in the lower jaw is more likely to arise from a defective articulation at the joint, but in either case, when taken at the proper age, it is quite amenable to treatment. It is not always advisable to attempt to alter the form and expression of a mouth where the condition is an inherited peculiarity—a part of the family type—and where the change would involve prolonged effort, with possible breaking up of a good articulation of masticating organs, and with the knowledge that nature will be constantly making an effort to return to the hereditary type. In hereditary cases of extensive deformity, in which interference has been delayed until at or near maturity, we can never feel certain but that the original tendency to malposition, so long unbroken, may reassert itself at any time that we abandon the use of retaining fixtures.

Upon general principles it is desirable to retain every sound tooth in the mouth, yet there are many cases of crowded dentition where the removal of a tooth upon each side of the jaw is justifiable. The retention of every tooth in the mouth is not necessary to the efficiency of the masticating apparatus, and is not required to maintain the contour of the jaw, while the loss of certain teeth produces no visible external effect.

The articulation of masticating organs is of more importance than their number, and a limited number of grinding teeth, fitting closely upon occlusion, will be of greater benefit to the individual than a mouth full of teeth with their articulation disturbed.

The treatment of irregularities is almost entirely mechanical. To the anatomical, physiological, and pathological knowledge required of the operator, there must be added a knowledge of mechanical science, and the ingenuity to apply it. Levers, pulleys, inclined planes, wedges, and elastics, singly and in combination, are required for this purpose. It is quite impossible for any

one to overcome a complicated dental irregularity, who has not a comprehension of each and all of these instrumentalities.

As far as pressure itself is concerned, it is immaterial from whence it is derived. The same weight, force, or power will produce the same result. It is only a matter of convenience what source shall be employed. For widening a narrowed arch, a jackscrew is the most effective means, and can be used to spread one tooth only, or all the teeth upon both sides according as it is applied. Wedges driven between the teeth will enlarge the arch. Levers, with elastics, are used to twist teeth in their sockets, and an inclined plane can be made to move teeth laterally. The application of such apparatus to effect the movement of teeth, is one of the most responsible duties the dentist is called upon to perform. Each and every one of these mechanical powers can be made to do his bidding, and equally each one of them may become a formidable engine of disaster. When applied to the mouth, they should have constant watchfulness and care. Not one of them but, in the hands of an empiric, may cause the destruction of those valuable organs which, when skilfully used, they can be made to conserve.

DENTAL CARIES.—Caries of the teeth depends on a constitutional condition which originates in an impairment of function, either in the individual or in his ancestors; consequently, on a condition which is common among highly civilized, and correspondingly rare among savage races. Civilization bears the same relation to caries of the teeth, that it does to other diseases which are incidental to, and the outgrowth of, a violation of hygienic laws. In a strong and healthy organization, where there is no inherited predisposition to caries shown in a defective organic structure, teeth will not decay excepting from want of nutrition arising from functional disturbance.

Like any other tissue of the body, the teeth require constant nutrition, or they will yield to external agents; but unlike other tissues, repair will not follow the return of nutrition. Excepting for defective nutrition, teeth of good organization, in a healthy body, will remain sound for a lifetime without care; while teeth with an inherited frail organization, and easily liable to decay, may resist for a lifetime adverse influences, by the aid of constant supervision and attention to bodily health.

Microscopic investigation shows that the organic matter of a tooth forms a reticular network, which traverses the entire structure, dentine, cementum, and enamel inclusive. It forms the matrix of the lime salts, and is the vehicle for the nourishment of the organism. Caries is a solution of the lime salts, originating always from outside influences favored by a congenitally frail organization, or by an acquired state of diverted or impaired nutrition.

External agents of an acid character are the sole local cause of decay, and by far the greater part of this decalcification is caused by acids produced in the mouth by fermentation—lactic, acetic, butyric, etc. All electrical conditions found associated with decay, as well as the presence of bacteria, micrococci, or leptothrix, do not constitute causes, but are incidental results.

Micro-organisms are always present in carious dentine, but it is very doubtful if they have the ability to penetrate beyond the layer of tissue softened by acids. In healthy conditions the saliva is alkaline, while the secretions of the mucous membrane are acid; but the teeth do not suffer from this acidity, because it is neutralized by the saliva, whereas in an unhealthy condition the mucous secretions may be in excess, or the saliva may become acid. Food in its fermentative stages, between the teeth, may contribute to this state. Starchy foods are found to give decided acidity, while animal food gives an alkaline or neutral reaction. The vulnerable points are found in fissures of the enamel in defectively formed teeth, which

permit the entrance of decomposing agents. In well-formed teeth, caries is most likely to begin upon the adjoining surfaces, where food has lodged and fermentation ensued. Caries in the beginning is almost always circumscribed and local, its progress being along the line of the dentinal tubuli, in the direction of the pulp, and more rapid in the dentine than in the enamel, because of its higher organization.

The teeth most liable to decay are the bicuspid and molars, upon their adjoining surfaces; and those least liable are the six front teeth upon the lower jaw, with the canines of the upper jaw.

There is another manifestation of caries, differing from that already described, which fortunately is not very common, but which is equally disastrous in its results and more difficult to combat. It shows itself in a general wasting of the buccal or labial surfaces of the teeth, sometimes forming great horizontal grooves near the gum, with clean polished surfaces, and with no trace of decomposed dentine.

The usual treatment of circumscribed caries is here seldom applicable. The cause appears to be systemic, and the wasting can only be arrested by a change in the general tone of the system; local and topical remedies are of little avail.

Treatment of Caries.—This is almost exclusively surgical and mechanical; medical remedies, independent of other treatment, are of little value. In some exceptional cases of shallow, superficial decay, if the affected part be removed with proper instruments, until sound dentine is reached, and if the new surface be polished, decay will not again set in. But probably in not one case in a thousand treated in this way, can caries be prevented from reappearing. As a general statement, there is only one course now known which can be regarded as effectual, viz., to cut out the affected part and replace it with some indestructible material which will close the orifice of the cavity absolutely.

The choice of the material to be used is of secondary importance. Anything which will be permanent and fluid-tight will meet the conditions, but some substances which have been used are much better suited to the purpose than others.

Gold, tin, amalgam, gutta-percha, and plastic materials, such as the oxychloride and oxyphosphate of zinc, are in common use. None of these substances, unless possibly the above-named plastic articles, possess any medicinal power upon tooth structure; the benefits derived from their use are purely mechanical—their office is solely to make a tight plug.

Gold in the form of foil or crystals has proven to be, in accessible cavities with strong walls, the best material. It will make a filling against which no objection can be urged, except its color, and even in that respect it harmonizes better with tooth-structure than any of the other materials named. Some of the efforts of operators in gold have been marvels of skill; by the aggregation of small particles, welded together as the work proceeds, whole crowns of teeth have been built up of pure gold. The discovery of the cohesive property of gold is due to dentistry. But for a large class of cases gold is not applicable, and if used may prove to be the worst material. For large cavities, its introduction involves great expenditure of time and force, to condense the filling properly, and consequently great danger of injuring frail walls. In the hands of injudicious though skilful manipulators, gold has frequently been productive of more harm than good. Frail walls have been weakened and shattered, and sooner or later disintegration of tooth-structure has ensued and the tooth been sacrificed. To some of the methods of using gold is attributable much of the damage that has occurred. After the discovery that gold could be welded under pressure, the mallet came into general use for condens-

ing the mass, and each particle of gold was hammered into solidity as it was introduced; automatic mallets, electric mallets, and mallets run by machinery were introduced, but by whatever force the mallet was propelled, there is no doubt of the injury which it caused, unless used with exceeding caution. A mallet is really unnecessary to the perfection of any filling.

The only advantage that *tin* has over gold, is that it is cheaper and can be introduced with less skill, but it is not as durable as gold, because in time it becomes completely oxidized.

Amalgam is now used under various names to disguise the fact that mercury forms one of its principal ingredients. Its composition is of silver and tin, about equal parts, alloyed and made into filings. These filings are softened and amalgamated with mercury, which gives the mass the property of setting or crystallizing in a short time, and becoming a piece of dense, solid metal.

A very small percentage of gold or platinum, or of both, is sometimes added, and the mixture is called "gold and platinum alloy;" but the addition of these metals does not give the composition any appreciable quality, and by whatever name it may be called, it is simply an amalgam. Very exhaustive experiments have been made within a few years, and all the resources of science have been brought to bear, to improve this filling material, until, as now made, it has all the good qualities that are ever likely to be obtained. The best article will not tarnish in the mouth, and will not shrink, and, excepting its color, seems to be as near a perfect metallic filling as is likely to be found. Although the color is a steel-gray, which it will retain, it is not a color that harmonizes as well with tooth-substance as that of gold, and is not as well adapted for fillings which are exposed to sight. The great advantage of amalgam is the readiness and certainty with which it can be used, and its indestructibility. No tooth has ever been made weaker by its introduction. At certain periods much prejudice has existed against the use of amalgam for a filling, because it contains mercury, but the observations of all unbiased practitioners, together with the most critical tests which can be made, show that this prejudice is groundless.

Gutta-percha is one of the best substances for filling teeth that has ever been discovered. The preparation employed is made by bleaching the gum, and adding a small percentage of mineral substance, thoroughly incorporated. For very large cavities upon the adjoining surfaces of the teeth, which reach under the gum, it has no equal. It is tolerated by the gum in contact with it as no other material is. It is not difficult of introduction, will not weaken a tooth in its application, and is insoluble. The objection to it is that it will not bear the abrasion to which a filling upon the grinding surfaces is subjected. Nevertheless, it is probable that if *every* filling which has heretofore been made of gold had been made of gutta-percha instead, more teeth would have been permanently saved.

Two other preparations in common use are worthy of mention: the so-called "oxychloride of zinc" and "oxyphosphate of zinc." They are prepared by first roasting the oxide of zinc of commerce, grinding, and then mixing, for one with muriate of zinc, and for the other with phosphoric acid. The zinc, being in a fine powder, when mixed forms a paste which sets almost instantly, and which makes a very hard substance, only soluble in the fluids of the mouth to a moderate extent. These are valuable preparations, particularly the "oxyphosphate" which seems to exert a medicinal influence upon the pulp of a tooth and upon supersensitive dentine. For fillings in children's teeth, it seems to be well adapted. It is also of especial value in large cavities near exposed pulp, where it may nearly fill the cavity and be finished out with gold.

The preparation of a cavity for filling requires delicate manipulation, in

removing the decay, and in shaping the cavity so as to assist in the retention of the filling. All that portion about the orifice which is decayed must be removed until sound structure is reached.

It is prudent to remove all softened dentine from the cavity, if it can be done without exposing the pulp, but it is very imprudent and unnecessary to remove all the softened dentine from the bottom of the cavity, if in so doing pulp-exposure is liable to occur. If any decay be permitted to remain, it should be treated antiseptically before the filling is introduced, and recalcification of that portion may be expected. When caries has advanced to the stage in which the pulp is irritated or inflamed, grave difficulties may be encountered. It is not yet settled what is the best treatment to pursue in all cases.

The earlier practitioners made no attempt to save a tooth after the pulp had become exposed. It was sacrificed to the forceps. This plan has been followed for a generation by that of destroying the pulp, removing it, and filling the vacancy even to the apex of the roots. The destruction of the pulp is brought about, in almost all cases, by the application of arsenious acid. The usual course is to make a paste of the arsenic with sulphate of morphia and a little creasote; a minute quantity, less in bulk than a small pin's head, is sufficient to devitalize a pulp; if, however, after two or three days, sensation still remain, the application may be repeated. At as early a date as possible after sensation ceases, the pulp should be removed. Small Swiss broaches which have been barbed, will enable the operator to do this in most cases of single-root teeth, but with the molars it is doubtful if every shred from each root is always removed. After as thorough a removal as possible, the remains, if any, should be treated with creasote, and the cavities immediately filled. Occasionally an operator may be found who will extirpate a pulp without the previous application of arsenic, but the treatment, while sanctioned by sound philosophy, is too heroic to be put into general practice. Within a few years, an outcry has been made against the devitalization of pulps, even after exposure; or, if pulpitis has occurred, the practice of attempting to restore them to health and usefulness is advocated. The method is to remove with much care all extraneous matter from contact with the pulp, and cap it in such a way that the superincumbent filling will not impinge upon it. A favorite plan is to make a thin paste of oxyphosphate of zinc, gently bring it in contact, and allow it to set, before the filling of the main cavity is undertaken. But the results have been far from generally successful, and it is still doubtful if it be the better practice in most cases to attempt to retain the pulp alive.

Before the introduction of any filling, the cavity should be made perfectly dry, and kept so during the entire operation. This can be done by taking a piece of bandage-rubber, punching a small hole in it, and slipping it over the tooth. Another important result is obtained by using this sheet-rubber even before the excavation of the cavity is begun. Softened dentine is hypersensitive; in sound dentine there is rarely any painful sensation from cutting, but decalcified dentine seems to be in a state of inflammation, and is easily irritated; by using the rubber-dam, as before intimated, the cavity of decay can be made dry by absorbents and by a jet of warm air; the complete drying of the irritable dentine destroys its sensibility. This is found to be the most successful method of obviating the sensitiveness of dentine, as almost every other means fails. Occasionally, an application of some escharotic appears to act beneficially, but long experience has shown these to be so unreliable that there is little use in resorting to them. Dentine is usually most sensitive when it borders upon the enamel, and least so in larger cavities as decay approaches the pulp. Free access to cavities is necessary to insure success

in filling them, and hence, if cavities occur upon adjoining surfaces of teeth which are in close contact, space must be made. Filing teeth for such a purpose is almost always unjustifiable. Space can be made by wedging. Wood, cotton, or rubber may be used for wedges, and in a few days sufficient space will be gained for operating. The teeth will resume their positions after the wedge is removed.

TOOTHACHE.—This arises more frequently from an exposed pulp than from any other cause. The next most frequent source of toothache is in the investing membrane of the root. This second form rarely, if ever, occurs while the pulp is living and healthy; in fact, inflammation of this membrane seems never to occur until after the pulp, for some cause or other, has died.

Toothache may arise also from other more hidden and less tangible causes. Ossification of the pulp, exostosis of the root, and the formation of so-called pulp-stones, are not uncommon sources of pain. Pain may be localized in a tooth which is quite sound, and the cause may be discovered to exist in some diseased tooth far removed from the aching member. Temporary pain may follow the eating of certain fruits or sweets, which come into contact with sensitive dentine through some minute crevice in the enamel; this is a common occurrence, in apparently sound teeth, and such pain does not always indicate that the affected tooth is decayed or requires filling. Aching teeth are sometimes only a symptom of systemic disturbance, and the cause must then be looked for elsewhere. Pulpitis and pericementitis are, however, the chief causes of this disease. Exposed pulps that have not taken on an active state of inflammation may be relieved of pain by the application of oil of cloves, creasote, oil of peppermint, laudanum, chloroform, tincture of aconite, phosphoric acid, and possibly many other remedies, any of which may be applied to the exposed pulp by saturating a small bit of lint, and gently placing it in the cavity of decay.

None of these have a tendency to immediately destroy the pulp. If devitalization is desired, a minute quantity of arsenious acid may be used with either of the foregoing as a menstruum. Toothache may sometimes be relieved by the external use of a lotion composed of equal parts of chloroform, laudanum, and tincture of aconite, applied on the cheek against the tooth, but particularly using it immediately behind the ear of the same side of the head. A last resource is extraction, which, except in very rare cases, is not justifiable. In many cases, neuralgia of the head and face is owing to dental irritation. Cavities of the teeth which do not reach the pulp, receding gums which expose roots too near their apices, and the encroachment of tartar under the gums, are among its fruitful causes.

“Any portion of the head, throat, or associate parts supplied by the fifth nerve, or indeed by its related nerves, may be the seat of reflex trouble from a dead pulp—thus we have odonto-gastralgia, odonto-cephalgia, odonto-cardialgia, etc.; even sciatica has been cured by the extraction of a diseased tooth.” Pain arising from exostosis cannot be diagnosed with certainty, but when it becomes evident that that is its cause, extraction is the only remedy known. Pericementitis, as before stated, only follows death of the pulp. In the earlier stages of inflammation, an application to the gum of a mixture of tincture of iodine and tincture of aconite, over the seat of pain, may afford relief; or the gum may be stippled with saturated tincture of iodine, thus establishing minute blisters. This failing, resort should be had to leeching, which, if done before suppuration has set in, will produce the desired result, but, if suppuration has begun, will be likely to aggravate the evil. If the suppurative stage has been reached, and the pain continues, poulticing or lancing is indicated.

ALVEOLAR ABSCESS.—In many cases of abscess at the roots of the single teeth, the pus may be reached without lancing, by passing a fine broach through the nerve canal. This is not difficult with the six front teeth, and is preferable to making an opening through the gum, unless the pus have already made its way through the alveolus. Alveolar abscesses are often difficult to cure, particularly when there are no fistulous openings, and when they have been of long standing. Opening into them through the canals of the roots, and treating them with antiseptics, is the usual course, but it is a common experience that this cure is but temporary. Latterly iodoform has been used in these cases, and it is claimed with perfect success. Oftentimes a chronic alveolar abscess can only be cured by heroic treatment, viz., making an opening through the gum and alveolus, cutting away the ulcerating sac at the root, and cutting and scraping away the devitalized bone in the immediate vicinity. Then cleansing the cavity with tepid water, to which a little salt has been added, a complete cure will be pretty certain to follow.

CYSTIC TUMORS of the jaw are of two kinds, simple and compound. The first show only expansion of the bone with varying fluid or gaseous contents, beginning as slightly flattened enlargements on the side of either upper or lower jaw, and slowly increasing until they reach the size of half a hickory-nut, but seldom larger. They are tardy in growth, unaccompanied by pain, and local in their origin, their occurrence being evidently attributable to dental irritation. The gum covering them always appears normal, without congestion, inflammation, or anything to indicate its implication in the disease. Their course is chronic and benign in character.

In some cases, pressure upon such a tumor will produce a parchment-like, crackling sound, but this is by no means general, as the outer wall, in many instances, will be found upon examination to be supported by a spongy growth or septa of bone, too firm to yield under any ordinary external pressure. The term "*spina ventosa*" has been applied to these cases. Treatment of such a cyst is not difficult. A crucial incision should be made through the body of the tumor, and such septa as exist should be broken up. No anxiety need be felt concerning hemorrhage. The cavity should be syringed with salt and water, or other slightly stimulating liquid, and stuffed with lint saturated with tincture of iodine. This will cause the base to throw out granulations, and the cure will be complete.

Dentigerous cysts are compound in their character, showing in addition to the contents of a simple cyst, elements of a dental nature, and owing their origin usually to an impacted or otherwise undeveloped tooth which lies imbedded in the jaw. Every impacted tooth, however, does not lead to the formation of a cyst. The cause of this condition appears to be: first, misplacement or diversion of a tooth-germ, so that in its growth it will not emerge from the gum; and secondly, the accumulation of serous fluid within the dental capsule, which thereby becomes distended, and, increasing in size, involves the surrounding tissues. Generally the crowns of teeth connected with dentigerous cysts are found to be normal, but their fangs are more or less abortive and defective.

A cyst may also arise from an unerupted supernumerary tooth. The latter can generally be recognized by its position and size, being seldom larger than an ordinary pea, and mostly situated in the palatine process of the maxilla. An exploring needle will readily determine its presence, if used by one who is familiar with the touch of tooth-substance. Dentigerous cysts sometimes assume a most formidable character, containing as their germ abnormal masses of dentine and enamel, unrecognizable as belonging to any

particular tooth—the distinguishing feature of a dentigerous cyst being simply the presence of dental tissue in some form or other.

These cysts may occur in any part of the maxilla, and their cause and character may be inferred from the absence in the arch of a tooth which is undeveloped. The cases are very rare in which a deciduous tooth becomes encysted. The teeth most frequently found in this condition are the superior cuspidati, and next in frequency the third molars; but a cyst may form about the crown of any impacted and unerupted tooth. The treatment of these cases is substantially the same as that indicated for a simple cyst—opening, evacuating the contents, and removing the imbedded tooth-substance, which is likely to be found opposite to or furthest from the thinnest part of the expanded wall. Such portions of the bone should be removed as may seem necessary, and the cavity should be treated with tincture of iodine. All cutting should, if possible, be done within the mouth.

PROTHETIC DENTISTRY.

This is a far more appropriate term to apply to the art of replacement than the designation of “mechanical dentistry” which this branch usually receives, since, strictly speaking, more than 90 per cent. of all the operations performed in dentistry are purely mechanical. The filling of every tooth cavity, with no matter what material, belongs to the art of replacement, and is as much a mechanical performance as the construction and insertion of artificial teeth. The term “mechanical dentistry” is unfortunate, too, inasmuch as it implies that the requirements for its practice are not above the level of ordinary mechanics, whereas the greatest achievements of prothetic dentistry demand artistic tastes and abilities far beyond those of mere mechanism.

Considering the universality of the need, the whole range of medical science affords no greater boon than that which replaces by art lost organs, and thus enables the functions of the human economy to go on uninterrupted. The truth of this proposition can only be realized by imagining all the artificial teeth now worn to be suddenly destroyed, and the art of making them forever lost.

Artificial teeth of a century since were generally carved out of ivory; porcelain teeth were then unknown. When a full denture was required, the teeth and the base which connected them were carved from a single block; and, as works of art, in imitation of nature, some of these dentures have never been excelled. Another plan of that epoch was to carve a base or plate to fit the gums, and upon that to mount the crowns of natural teeth which had been obtained from other sources. Experience soon demonstrated that ivory was subject to the same influences, when used in the mouth, as the natural teeth, and that it became offensive and useless from deterioration and decay. In the early part of the present century, gold and silver plates were substituted for ivory, still using natural crowns for teeth, but as these also in a short time decayed and became useless, porcelain crowns were introduced. The first teeth of this material were made by the French, but were exceedingly rude and unsightly; very shortly after, that is, about 1830, American dentists began their manufacture, and to day the art is carried to almost absolute perfection, and the American manufacturer now supplies almost the entire demand throughout the world.

These teeth are composed of quartz, feldspar, and clay, in proportions of about five parts of spar, two of quartz, and less than one of clay, ground into an almost impalpable powder, mixed into a plastic mass, and moulded or carved into form. Platinum pins are inserted, to facilitate their ultimate

attachment to the plates. Teeth and gums are made of the same material, the difference in coloring being due to enamels. These moulded forms are subjected to a heat of more than 2000° F., to vitrify them and develop their colors.

There are four chief varieties of artificial denture, according to the principle upon which they are inserted and sustained, viz: (1) Pivot-teeth; (2) Plates with clasps; (3) Plates sustained by atmospheric pressure; and (4) Plates of simple adaptation.

A PIVOT-TOOTH is a single artificial crown, secured by a pivot to a natural root, and only applicable where the crown of a tooth is gone, and where a sound and healthy root, to which the artificial crown can be attached, remains in the jaw. The use of pivot-teeth is of very ancient date, going back to classic times, and possibly earlier. A generation since they fell into disuse, but within a few years have been revived, and, under a score of different names, but applying the same principle, are now extensively inserted. Where roots are sound and in a perfectly healthy condition, the adaptation of pivot-teeth is, when skilfully executed, without exception the most convenient and most useful for the patient. Formerly the tooth was simply fitted to the root, which was cut off close to the gum, and secured by a pivot of wood, generally of condensed hickory. This plan fell into disuse, because the junction was never so perfect but that the fluids of the mouth would act upon the root, causing decay and loosening the pivot, when in a short time the crown would become useless. At the present day, there is one plan which is entitled above all others to a claim of superiority. It is to fit a thin, narrow band, or ferule, accurately around the stump, and to push it just under the edge of the gum, and to this ferule to attach the artificial crown by soldering. The ferule protects the joint and prevents decay. Additional strength is also given to the crown by screwing it to the root. Another variation of much value is to make the entire crown of gold, hollow like a shell, and fitted to and over a stump. This method is not applicable to the front part of the mouth, because the crowns have the appearance of solid gold, but for the bicuspid and molars it is a very valuable form of restoration. Still another variation of this plan may be used sometimes with excellent results when two or three teeth are missing. In such cases two crowns are secured to the roots, as above described, but they are also connected with each other by a bridge or bar, to which are attached the other missing teeth. Thus two sound roots may be made to support the crowns of several others. The advantages of pivot-teeth are cleanliness, security, utility, and the absence of any covering to the natural gums.

PLATES WITH CLASPS are applicable to either jaw, when there are two or more remaining teeth separated from each other and firm in their sockets. This is the best plan (where plates, as a base upon which to set the teeth, must be used) that can be devised, wherever admissible. The plate which bears the artificial teeth is sustained by clasping to the natural ones. Objections have been made against clasped plates, that the teeth are injured which sustain them, but this objection loses all its force when the work is skilfully executed. It is only bungling and ill-fitting clasps and plates that do the damage. The advantages are that greater security is given than with other forms of plates, and that a less surface of the gum is covered.

PLATES HELD BY ATMOSPHERIC PRESSURE are the last resort for an upper denture when all the natural teeth are gone. There is then no other plan which can be resorted to which is not more objectionable, and therefore unne-

cessary to notice. With atmospheric-pressure plates the whole of the roof of the mouth must be covered, even to the posterior border of the palatine bone. The application of the plate is secured by raising its central part from contact with the roof, and creating a defined chamber of from one-half to three-fourths of a square inch of surface. If the plate were accurately adapted, and if all the air could be exhausted from such a chamber, thus creating a perfect vacuum, a pressure of from eight to ten pounds would be obtained, and the plate would sustain such a weight before it would drop; but, practically no such security is ever reached. The adaptation is faulty, and, consequently, the most that is ever attempted or expected, is to get stability sufficient to bear the tipping strain of mastication. In practice this can usually be obtained, and in mouths where the mucous membrane is thin and hard over the bones and processes, such an amount of adhesion can be secured without difficulty; but where the gums are thick and spongy, exuding more or less viscid, mucous fluid, real suction is almost impossible. The retention of plates under such conditions is due not as much to atmospheric pressure as to simple adhesion.

FULL DENTURES FOR THE LOWER JAW are retained only by the accuracy of their adaptation, and by their own weight. Ordinarily they are far more troublesome for a patient to manage than those for the upper jaw. The muscles of the tongue and cheeks are continually lifting them out of place, and sometimes no amount of weight will keep them quiet. As a general rule, it will be found that the older patients are, the more intolerant they are of weight. So that while younger patients will tolerate and be benefited by all the weight that can be obtained, old patients must have as little weight as possible. It is because of the want of stability of all full lower dentures, that it is particularly ill-advised to remove all the teeth from the lower jaw, even when only one remains, if it is firm enough to give steadiness to the artificial denture. The retention of one tooth, anywhere upon the lower jaw, is of untold value in adding to the comfort of the patient.

The requirements of dental prosthesis are frequently more than a mere restoration of masticating apparatus. With the loss of the alveolar processes, comes an entire change in the external form of the face and in its expression. A restoration of expression involves artistic study and ability, and the bases upon which the teeth are set often have to be built into peculiar shapes to produce such results. In some cases, plumpers as large as filberts are needed to fill out the sunken cheeks. There is no loss of alveolar processes or adjoining maxillæ, however extensive, consistent with the life of the patient, that may not now be measurably restored by mechanical skill. Large portions of either or both jaws have been carried away by gunshot, and the comfort of the patient and his masticating ability restored by nicely adjusted prosthetic appliances.

The bases upon which artificial teeth are set are of two sorts—metallic and plastic—each with its advantages and disadvantages. Platinum, gold, silver, tin, aluminum, and some compositions, of which tin forms the main part, have been found useful. Vulcanized rubber and celluloid are the two chief plastic substances which have been used for the same purpose. Each one of these materials finds its place and its advocates, but they are not all equally desirable, in regard to either durability, comfort, cleanliness, or health. Gold and platinum rank first, because of their strength and purity. They are not acted upon by the fluids of the mouth, and a strong, delicate, and artistic piece of workmanship can be made from them. With very little care, a set of teeth thus made can be kept clean, sweet, and free from odor. The objections to gold

or platinum lie only in cases of full upper sets, generally for elderly persons, where long teeth have to be added, which, together with an artificial gum, make a set of great weight, and liable to overcome the suction-power by which it is held in place. Excessive weight is an objection in upper sets, but has no disadvantage in lower ones, except for very old people. Therefore the material which might be the best for a lower set might be the worst for an upper one.

In nearly all cases, save those named above, gold or platinum is much the best, for either partial or full upper dentures.

Silver possesses some of the advantages of gold or platinum, and is much cheaper. The objection to it is that it is not as strong, not as durable, and not as easily kept clean. It discolours readily, and in time is eaten up by the acid secretions of the mouth. Aluminum is rarely used. It possesses an advantage over other materials in being the lightest of all known metals, but there has not been sufficient experience with it in dentistry to justify its general use. Tin is a very valuable metal as a base for teeth, especially for full lower sets. It is a pure metal, not easily oxidized, readily worked, and quite durable. For a lower set, where economy is necessary, it has advantages over any other material. It is strong, readily repaired, and can be kept clean without difficulty. Since the discovery of vulcanite, or hard rubber, it has been extensively used as a base for artificial teeth. Its popularity has come from the ease with which an unskilful dentist can put together a useful set of teeth upon it, and its consequent cheapness. Its advantages lie in the readiness with which a fit can be obtained, and (when not too clumsy or bungling) in its being lighter than any metal, and thus admirably adapted to make sets for the upper jaw. The objections to it are that it is brittle, and, except when great thickness is used, wanting in strength, and continually liable to break down; that it is impossible to repair it and make it as good as new; that, being a non-conductor, it has a constant tendency to inflame the gums, making them soft and spongy; and that it is almost impossible to keep it sweet and clean. The advantage which its lightness gives it for an upper set makes it equally objectionable in most cases for a lower one.

Recently, celluloid has become a rival of vulcanite. Celluloid is a combination of cellulose and camphor, and is of about the same strength, elasticity, and durability as vulcanite, and as easily worked. The only advantage which it thus far seems to possess over vulcanite is in its translucency and color, which is a close imitation of that of the natural gum; but this is offset again by the fact that in a little time it loses its color and has a dirty look. It is open to the same objection as vulcanite, in the difficulty of keeping it clean.

Artificial teeth require more care than they commonly receive, and so does the mouth while they are being worn. The idea that as soon as the natural teeth are gone and replaced by artificial ones, all care is at an end, is a fallacious one. More care is required to keep them sweet, and the gums healthy, than the natural teeth would have demanded from the same person. They ought not to be worn night and day. Any suction plate, whether full or partial, will injure the roof of the mouth, sooner or later, if constantly worn. No appliances can be worn in air-tight contact with any part of the human organization continuously, for months and years, without producing injurious absorption. In the mouth, the gums become inflamed, spongy, and diseased, as the result of such contact. This state of things is aggravated by want of cleanliness on the part of the patient.

Simply rinsing off a set of teeth does not make them clean. Particles of

food will accumulate upon the plate, and in the crevices, and within a few hours will ferment and make the set foul, and nothing but a liberal scrubbing with a brush, and often with some alkaline wash, will sweeten it. With small plates, clasped to adjoining teeth, constant care is needed to keep the inside of the clasps absolutely clean, and also the natural teeth which the clasps surround, or the teeth will rapidly decay. The plates which are least liable to do injury to the gums, are those of gold and platinum, and those which are most injurious are of vulcanite. There are three objections to vulcanite plates, viz.: the character of the material, the poor workmanship usually employed in making them, and the lack of care which is taken of them. The first objection is inherent and unavoidable; the second shows itself in all cheap work, the surface which comes in contact with the gum being left rough and unfinished; and this makes it more difficult to cleanse the plates properly. On retiring at night, all artificial teeth with plates should be removed from the mouth and thoroughly brushed with soap and water, and afterwards scrubbed with pulverized chalk. They may then be placed in a glass of water, to which a little common soda has been added, and left until needed in the morning. Teeth should also be removed and brushed after each meal, if the wearer desires to meet his associates without a foul breath. If the gums are inclined to be spongy, the ball of the thumb should be wet with tincture of myrrh, and all the spongy surface rubbed daily until it becomes harder.

By this process the suction-power which keeps an upper plate in place will be increased. Artificial teeth will not last a lifetime. The average period during which they are worn without renewal is but a few years. This results from several causes: the perishable nature of the materials used; ordinary wear and tear; liability to accidents; but more than all, the constant shrinkage of the gum, which goes on to some extent as long as life lasts, and on account of which the plate loses its adaptation and usefulness.

METHODS OF MAKING ARTIFICIAL TEETH.—An impression of the space desired to be filled is taken in some plastic material. Plaster of Paris, gutta-percha, beeswax, and some composition of beeswax and various gums, are the materials commonly used. The last three are prepared by heating until they become sufficiently plastic to receive an imprint without disturbing the soft tissues. Plaster of Paris is the most reliable substance for the purpose. The best method of preparation is to take the desired quantity of water, and to drop gently into it all the plaster that the water will take up. Beat it well together by stirring, thus freeing it from all air-bubbles, and it is ready for use. If it is desirable to have it set very quickly, add a teaspoonful of salt to each pint of the water used. Good plaster mixed in this way will set in about sixty seconds.

An impression made of plaster of Paris shows the most minute details of structure. Wash the impression with a lather of soap, rinse it off, and pour other plaster into it; an accurate model of the parts is thus obtained. When metallic plates are required, such a model is duplicated by moulding in sand, and casting zinc, thus making a die; the counter-die is made of lead, and between these the plates are swaged with a heavy hammer.

A plate thus made should fit the mouth or parts required accurately. The teeth are attached by the platinum pins which were baked into them at the time that they were made, and are connected with the base by linings and solder. A set of artificial teeth mounted skilfully on gold, will show all the artistic finish of a piece of fine jewelry, besides being so nicely adjusted to its place that it can be worn with entire comfort.

The highest order of mechanical and artistic talent is capable of development and display in making prothetic apparatus of this kind. The use of

vulcanite or celluloid involves but little exercise of the same abilities. The method used for those substances is quite different. No dies are required, but, instead, the teeth are arranged upon the plaster model; they are kept in position by a base of sheet-wax, and wax is also used to build up the form of the denture desired. This form is inclosed in a flask and surrounded with plaster, after which the wax is removed and its place filled with rubber which is prepared for the purpose. The rubber is vulcanized at about 320° Fahr., for one hour, and thus becomes a permanently durable substance.

Celluloid is treated in much the same manner, excepting that it is not vulcanized, but is forced into the shape of the mould under great pressure, at about the same temperature.

Vulcanite has been an inestimable boon to thousands of impecunious edentulous people, but it has been a curse to "dentistry as a fine art."

MECHANICAL TREATMENT OF LESIONS OF THE PALATE.

Lesions of the palate are either congenital or acquired. With a loss of any portion of the palate, whether congenital or accidental, sufficient to make a permanent communication between the buccal and nasal cavities, the perfect articulation of any spoken language is impossible.

The chief evil arising from congenital cleft palate which demands the interference of science and art, is the defective articulate speech. The effect upon the speech varies much with different individuals. It does not seem to depend upon the shape or the extent of the fissure, or upon the intellectual status of the patient, as much as upon some other influences which are not easily determined. No physiologist, however large his experience, can tell with certainty, by simple observation of such a fissure, all the articulate sounds which will be defective.

The peculiarities of speech shown by persons with cleft palate, form a very interesting study. In most cases which have come to my knowledge, the sounds of K and G have been wanting, but I have seen other cases of intelligent and fairly educated people, with whom every consonant sound of the English language has been defective excepting those of K and G.

Aside from the inability to articulate, the resonating tone-power of both buccal and nasal cavities becomes entirely changed by their partial or complete union, or by the change in their form or dimensions, so that the speech of a person with cleft palate becomes altered in tone, indistinct in enunciation, difficult and sometimes impossible to understand, and altogether disagreeable. To such an extent has this condition operated on sensitive minds, that it has, in the absence of relief, sometimes driven the sufferers from society, and made them utterly wretched.

Such an affliction is sufficient to call forth all the resources of science in producing a remedy. The only thought which has seemed to govern surgeons in adopting the operation of staphyloraphy, has been that a roof to the mouth of natural tissue must be better *per se* than no roof, or than an artificial one, but although the operation has been tested in a thousand cases by the most eminent surgeons of their time, it has resulted in such an uniformity of failure, considered as a beneficent operation, that it should, in my judgment, have been long ago abandoned. Without a complete understanding of the physiology and function of the velum and pharynx, it would be a natural supposition, that, as there are evils arising from a fissured palate, if the cleft could be closed, the evils would pass away; but a better knowledge of these functions in the mechanism of speech, shows that it is impossible to correct such defects

by surgery, and a lifetime of experience has demonstrated the correctness of this statement.

The *velum palati*, as an organ of speech, is second to no other in importance. It is hinged like a valve to the edge of the palatine bone, while its posterior border may be elevated or depressed by the action of muscles. It can be raised until it comes into close contact with the walls of the pharynx, and thus shuts off all passage through the nares, or it can be depressed until, meeting the dorsum of the tongue, the passage through the mouth is stopped; or, again, it may hang midway between the oral and the nasal cavities, and thus sounds emitted from the larynx may pass through both mouth and nose.

But for the performance of these functions the velum must be free from perforation or fissure, and must be of such length that when elevated it will meet the pharyngeal wall. If a natural velum without a cleft has not this requirement, it cannot perform fully the function of articulation. It would interfere as much with perfect articulate speech as if it were fissured, perforated, or in any other way defective. Articulate speech is dependent in its perfection not only upon the integrity of the velum, but also upon the activity of the pharyngeal muscles. The closing of the posterior nares is due equally to the elevation of the velum palati and to a simultaneous advancement of the pharyngeal wall. This function of the constrictor muscles of the pharynx is seldom recognized. The pharynx is an important organ of speech in normal articulation, and in the effort to articulate with abnormal organs it develops an activity and a power at times truly wonderful. Indeed, in some instances the superior constrictor of the pharynx, in conjunction with the tongue, has, in cases of absence of the palate, enabled the patient to make many sounds which in normal articulation are dependent upon the integrity of the latter. The failure of surgery has not been in its inability to bring the edges of the divided velum together, and to get union, but it has been in the fact, before pointed out, that the newly formed palate which results from staphyloraphy is always too short, that its posterior edge does not and cannot be made to reach the pharynx, and that the speech will necessarily be defective, in spite of the operation, save in some extraordinary cases. As an operation, it is with justifiable pride that the surgeon may view the result of his work in seeing a complete union throughout the entire length of the fissure, including the uvula, and apparently a normal septum where before was a gaping orifice; and thus he may lose sight of, first, the fact that this new palate has very little muscular power as compared with the normal organ, owing to the injury which its muscles have received in the operation, and, second, that it is defective in dimensions, because there never was tissue enough to make a velum which would bridge the chasm in both its breadth and length.

The origin of the fissure is in lack of a development of sufficient material to come together and make a perfect septum, and no division of the muscles or stretching of the tissues subsequently will make up for developmental deficiency. A successful operation, surgically considered, has often been not only valueless but productive of positive harm. The new velum becomes a rigid curtain which splits the column of sound in its upward ascent, and renders it less manageable even than it was before. In early life a patient with cleft palate acquires a certain control over his voice, and a measure of articulation which a non-elastic and immovable curtain deprives him of.

As operative surgery fails, prothetic surgery comes to the rescue. Where nature is deficient she may be supplemented by art, and an organ whose function has been destroyed by accident, disease, or want of development, can have that function restored by properly adapted apparatus. The restoration of speech to a person who has once possessed that faculty, and who has lost it through a destruction of the palate, is comparatively easy; but to confer the faculty of

perfect speech with an artificial organ upon one who has been afflicted from birth with the absence of the natural organ, and has grown to maturity without the ability of distinct utterance, is a much more difficult problem. In acquired lesions, even crude appliances, made without much skill or accuracy, are often beneficial; while in congenital cases the full resources of science and the nicest adaptations of art are needed to accomplish the desired result. The partial destruction of any organ of speech may occur after the acquirement of speech, and nature makes an extraordinary effort to overcome the difficulty by increased use and activity of other organs which in a measure supply the deficiency. Thus, total loss of speech will follow the destruction of the hard palate, but instant restoration will result upon the introduction of proper apparatus. But in a congenital case the faculty of perfect speech must be acquired by practice, even after the introduction of the most skilfully constructed and scientific appliance.

APPARATUS FOR CONGENITAL DEFECTS may be of two sorts. First, the gap may be filled with an elastic, movable appliance, so constructed that it will grasp the remnant of the velum upon each side of the fissure, and be lifted or depressed by the movement of the adjacent muscles. Such an instrument must be made long enough to reach the pharyngeal wall when that wall is advanced by the action of the constrictors. The elevation of the artificial palate by the levatores palati, together with the advance of the pharyngeal wall, as before indicated, will form a conjunction which will permit the perfect articulation of oral sounds, while the nasal sounds will be heard when the muscles are relaxed and the voice passes by the nares. The second form of apparatus for congenital cases depends for its usefulness entirely upon the activity and control of the constrictors. It is non-elastic and immovable, the part occupying the cleft is made bulbous, and with this bulb the pharyngeal wall comes into contact during constriction.

The first form is applicable to all congenital clefts. The second may be used where the superior constrictors are well developed and active.

The objections to the first form are that the movable part, being made of elastic rubber, must be renewed from time to time, and that the patient is not quite as independent as with the more durable, non-elastic apparatus. The objections to the latter are that it is not always as certain that the wearer will learn to articulate with it as with the elastic instrument, which more nearly fulfils the function of the natural organ in movement. With neither kind will perfect articulation follow immediately, but must be acquired by persistent and thoughtful application and practice.

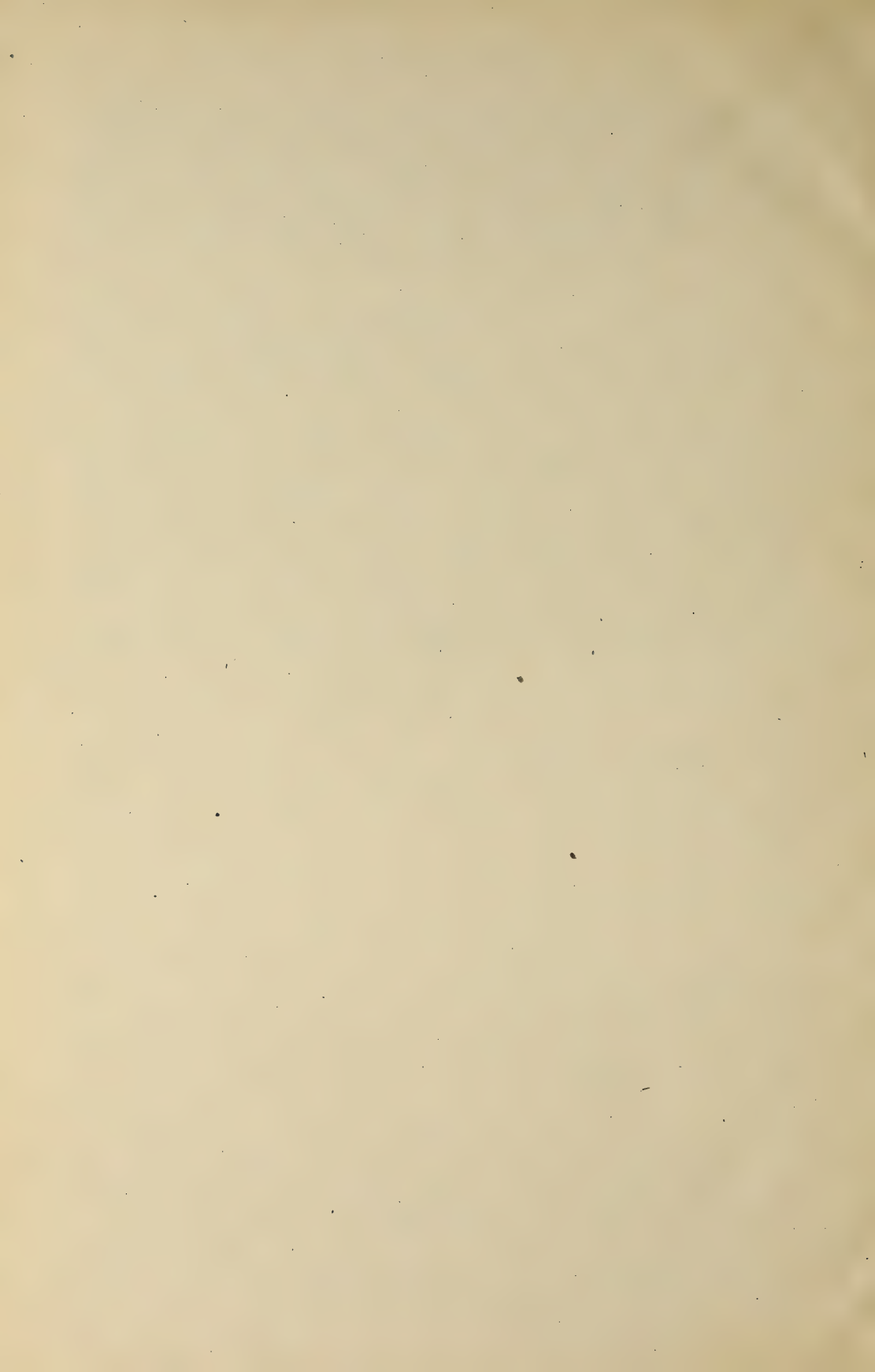
The benefit to be derived from the use of an artificial palate depends upon the intellectual status, the application, and the perseverance of the patient. The responsibility for the result rests solely with the patient, after the appliance best adapted for the purpose has been introduced. Results cannot be guaranteed. All that can be said is, that appliances can be made which can be worn with freedom from discomfort, and that a large number of persons have made such use of them as to completely hide in their speech any evidence of their deformity.

The improvement is sometimes rapid and remarkable, in other cases slow and tedious—showing in the latter a want of application, an insensibility to the defect, and a dulness of capacity on the part of the patient. The result must be accomplished by the same character of attention and training as would be given by an adult to the mastery of a foreign language, or of a musical instrument.

There is no limit to the age during which such instruments may be introduced, but as bad habits or peculiarities of speech become more and

more fixed and incurable the older one grows, even with normal organs, it is more encouraging to begin at the earliest age practicable. But little will be gained, however, by introducing such apparatus into the mouths of mere children, before they are of an age to realize its importance and to coöperate with the efforts made in their behalf. As a general rule, it is quite as well to await the eruption of the twelfth-year-old molars, after which period there is but very slight enlargement of the jaws, or increase in the size of the fissure.

ACQUIRED LESIONS OF THE PALATE are corrected by mechanism far more readily and with much greater certainty than are the congenital. The effect upon speech of any pertoration of the palate which permits abnormal escape of sound to the nasal cavity, is disastrous, but the remedy comes instantaneously when the proper apparatus is introduced. Appliances for congenital cleft tax the utmost ingenuity of the maker, but the requirements for acquired lesions may be of very simple character. Anything which can be worn over or in the orifice, which will interrupt the passage, will restore the faculty of speech; so that the instrument may be made of any of the materials used as a base for artificial teeth, and requires to be but a cover or stopper to the opening, nicely adjusted, and secured generally to some adjacent teeth. In all lesions of either the hard or soft palate which are of moderate extent, and which do not reach to the posterior border of the velum, it is unwise to permit an obturator to pass into the opening, thus preventing the diminution of the orifice and its possible final closure. Small openings will sometimes completely close, with no other treatment than covering the orifice.





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